A MANUAL

OF

OPERATIVE SURGERY.

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WITH 422 ILLUSTRATIONS.

VOL I.

GENERAL PRINCIPLES—ANÆSTHETICS—OPERATIONS UPON ARTERIES AND NERVES—AMPUTATIONS—EXCISIONS—OPERATIONS UPON BONES, JOINTS, AND TENDONS.

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PREFACE.

THE present work concerns itself solely with the practical aspects of treatment by operation, with the technical details of operative surgery, and with such part of the surgeon's work as comes within the limits of a handicraft.

With the indications for operating I have not dealt, nor have I entered into the subtle questions, the anxious reasonings, the spectral doubts, which lie without the operating theatre.

Into the mysteries of surgical statistics I have ventured also with but reverent caution.

For the selection—out of the vast and bewildering collection provided by the literature of Surgery—of particular methods of operating I must hold myself answerable. I have selected such measures as have appeared to me to be the best, and have made no attempt at encyclopædic completeness.

The majority of the descriptions are founded upon personal experience in the operating theatre, and upon repeated operations on the dead. The account of such particular methods as are associated with the names of individual surgeons I have endeavoured to give in the actual words of the authors.

In each section I have included details as to the preparation of the patient and the after-treatment of the case, and have discussed the comparative merits of the various operations described.

The illustrations have been executed by Mr. Charles Berjeau, to whose artistic skill and much-tried patience I am greatly indebted. The majority of them have been made

from sketches of my own. Such as have been derived from other sources are, I hope, fully acknowledged.

I am much obliged to the proprietors of the *Lancet* for kindly lending me the blocks from which Figs. 237 and 238 are printed.

The figures of instruments are for the most part copied from Weiss's Catalogue.

The whole of such leisure as I could obtain during the last four years has been devoted to the writing of this book, and I have done my best to render it complete as a Practical Manual of Operative Surgery: but I would rather rely upon the reader's indulgence than upon these extenuating circumstances when the many shortcomings of the book have to be judged.

6, *Wimpole Street, London.*
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A MANUAL OF

OPERATIVE SURGERY.

Part I.

GENERAL PRINCIPLES.

CHAPTER I.

THE PATIENT.

1.—THE CONDITION OF THE PATIENT AS IT AFFECTS THE RESULT OF AN OPERATION.

"NEVER decide upon an operation, even of a trivial kind," writes Sir James Paget, "without first examining the patient as to the risks of his life. You should examine him with at least as much care as you would for a life insurance. It is surely at least as important that a man should not die, or suffer serious damage, after an operation, as that his life should be safely insured for a few hundred pounds."

In the case of urgent operations, performed for the immediate purpose of saving life—as in the relief of a strangulated hernia—few considerations weigh with the surgeon save the one great need. But in slight operations, in amputations for deformity, in the removal of small, innocent tumours, in the carrying-out of plastic procedures, and in like surgical undertakings, it is of infinite importance that every possible consideration be given to all circumstances which may affect the patient's well-being.

No operation is without risk; some involve special risks; some overwhelming risks. It is the surgeon's duty to estimate the proportion between the danger incurred by the

operation on the one hand, and by the disease if left untreated on the other.

The risk attending the removal of a deformed toe should be infinitesimal. In properly selected cases it is certainly trifling. The operation, however, may be followed by dangers to life if it be carried out in the subject of chronic kidney disease.

If the mortality attending ovariotomy were to be increased threefold beyond the present percentage, the operation would still be justifiable, inasmuch as the death-rate in untreated cases is so high as to leave but little prospect of life.

On the other hand, were the death-rate of hysterectomy lower by threefold than it is, it would not sanction the performance of that operation on account of a small fibroid tumour which had ceased to grow, which produced no symptoms, but which the patient, as a whim, was determined to be freed from.

If a patient wishes to be rid of a mere inconvenience, or of some real or imagined blemish, it is exceedingly important that the precise risk at which relief may be obtained is clearly ascertained.

Besides the risks to life, there are possibilities to be considered which may be termed local risks.

The little operation for the relief of Dupuytren's contraction of the palmar fascia has led to sloughing of the tissues of the hand and a crippling of the limb infinitely more severe than that attending the original disease.

I have known an operation for the removal of a small exostosis of the femur, which caused little inconvenience, lead to suppuration of the knee and a final anchylosis of the joint.

An operation for harelip carried out under unfavourable circumstances has left the deformity worse than it was before.

It is of the utmost importance, therefore, that every care should be taken to arrive at a knowledge of the physical condition of the individual upon whom even a small operation is to be performed. Every surgeon must have met with instances where he has regretted the neglect of this fundamental precaution. I once snipped off with the scissors a small fibrous epulis growing from the gum of a little boy. I discovered afterwards—what I should have known before—

that the patient was the subject of hæmophilia. The small wound became the seat of almost uncontrollable hæmorrhage, and it was not until a fortnight had elapsed that the patient could be said to be out of danger. In another case, I removed—at the patient's urgent request—a small sebaceous cyst from the scalp of a man of fifty. The wound soon broke down, suppurated freely, and became the starting-point of a low form of erysipelas, of which the patient nearly died. It was discovered after the operation that the man was suffering from diabetes, a fact of which he himself was not aware.

In forming a proper estimate of the risks involved by operations—so far as the condition of the patient is concerned—many factors have to be considered, and in the paragraphs which follow the more important are dealt with.*

Age.—Age exercises a considerable effect upon the result of operations. Taking amputation as a typical operation, it appears that quite young children—those under the age of five—do not bear operation well, the mortality being as high as between the ages of thirty-five and fifty. The mortality is lowest between the ages of five and fifteen, and these years certainly give the best results from operations of almost every kind. After fifteen the death-rate begins to steadily but slowly increase. The variation between the whole period from twenty to forty is certainly not considerable; but the risk of death after operation is twice as great in patients between those ages as it is in individuals under twenty. In patients over forty the mortality is nearly three times in excess of the rate observed in patients under twenty. The increase in the risk of death between fifty and seventy is very rapid.

In *children* wounds usually heal well; the patient's organs are healthy and vigorous, and the nutritive activity of the body is in its prime. Children show great recuperative power, and are free from the effects of that mental anxiety which often acts so injuriously upon adults. They are able,

* Considerable use has been made of Sir James Paget's classical Lecture upon the subject. The question of the effect of the operation itself is alone considered. The special risks attending the administration of anæsthetics and the circumstances modifying those risks are considered later (page 78).

moreover, to stand long confinement in bed, and to endure a tedious suppuration with comparatively little ill effect.

On the other hand, children suffer severely from shock and the effects of acute pain. Pain, if unrelieved, may in a few hours reduce a child to a state of collapse. Mr. Howard Marsh cites the case of a child, two years old, who "died apparently of the pain and terror caused by the repeated dressings of a burn on the trunk and lower limbs."

Shock is certainly the chief danger in operations upon young and healthy children.

It has been said that children bear the loss of blood badly. Mr. Marsh has questioned the soundness of this belief, and with his view I entirely concur. Hæmorrhage must be regarded relatively when comparing children with adults. If the weight of the body be taken in conjunction with the amount of blood lost, I think it will be found that children bear hæmorrhage well, and, in the case of repeated bleedings, often remarkably well.

Operations should not be performed, if possible, during the first dentition. Children are then often restless and excitable, liable to digestive disturbances and to convulsions, and apt to develop a high temperature under little provocation.

The natural restlessness of children is often an obstacle to the perfect success of an operation, and operations in the region of the pelvis are apt to be complicated by the difficulty of keeping the child clean.

It is essential for the good result of a plastic operation that the child should be in sound health. Any history of convulsions should be sought for; and the operation should be postponed if the patient has recently been exposed to the risk of infection from any of the exanthemata.

The remarkable effect an operation now and then appears to have in determining the appearance of scarlet fever is well known.

Of the influence of *old age* upon operations, Sir James Paget writes:—"Among the old there are even greater differences than among the younger in the ability to recover from operations; and age, if reckoned by years, is not the only thing in them we must estimate. . . . They that are fat

and bloated, pale, with soft textures, flabby, torpid, wheezy, incapable of exercise, looking older than their years, are very bad. They that are fat, florid and plethoric, firm-skinned and with good muscular power, clear-headed and willing to work like younger men, are not, indeed, good subjects for operations, yet they are scarcely bad. The old people that are thin and dry and tough, clear-voiced and bright-eyed, with good stomachs and strong wills, muscular and active, are not bad; they bear all but the largest operations very well. But very bad are they who, looking somewhat like these, are feeble and soft-skinned, with little pulses, bad appetites, and weak digestive power, so that they cannot, in an emergency, be well nourished.

"The old are, much more than others, liable to die of shock, or of mere exhaustion, within a few days after the operation. They bear badly large losses of blood, long exposure to cold, sudden lowering of temperature, loss of food. Large wounds heal in them lazily. Their stomachs, too, are apt to knock-up with what may seem to be no more than necessary food—though, indeed, it often is so; for many old people are in less peril with a scanty diet than with a full one. Their convalescence is often prolonged. . . . There are some to whom convalescence is more dangerous than disease.

"You must choose for the old, if you can, short and gentle operations, and be sparing of hæmorrhage, and make wounds that may not lead to long suppurations. You must keep them warm, and not feed them beyond their real necessities, nor keep them long recumbent. In all their convalescence you must be constantly on the watch for latent mischief. Your cares must be doubled when your operations are on the lower limbs, or the lower part of the trunk, or on the back, for in operations on these parts the risks, both local and general, are much greater than in the parts above the heart. . . . Let me add that of all the conditions of disease or imperfect health which influence the results of operation, there is no graver complication than old age, unless, indeed, it be habitual intemperance."

Sex.—Other things being equal, it would appear from statistics that women bear operations somewhat better than men. This fact may be explained by the circumstance that

they are more tolerant of confinement to house and bed, lead less active lives, and adapt themselves more easily to the surroundings of an operation ward. They are probably more temperate and regular in their lives, and owe not a little to a certain natural determination and patience.

It is well not to operate, unless compelled, during menstruation. In perhaps the larger number of instances of operations performed during this period no ill effects are noticeable; in the minority an unaccountable rise of temperature, with often considerable nervous and digestive disturbances, are met with. In more than one instance I have observed somewhat severe vomiting, with undue abdominal pain. The operation may hasten by several days the appearance of the natural menstrual period, and it may be then attended by unusual symptoms of excitement and of general irritation.

Still more desirable is it that no operation should be performed during pregnancy. The special risk incurred in such a case is that attending abortion. Apart from this risk there is little to anticipate, and wounds do well. Ovariotomy and other grave abdominal operations have been performed during the various stages of pregnancy without inducing abortion and without evil results. It appears to be impossible to estimate the possibility of miscarriage after any surgical procedure.

During lactation, also, operations should be avoided when possible; the patient is usually in comparatively feeble health, and certainly not in the best condition for a serious call upon the nutritive powers. Operations performed during lactation have, however, done well enough, with the emphatic exception of operations upon the breast. Fatal hæmorrhage has in more than one recorded case followed an incision made into the active mamma.

The Robust and the Feeble.—Experience shows that the best subject for an operation is not the strong, lusty man in the prime of life. He may have mighty limbs, and immense strength and endurance. He may boast that he has never had an ache or pain in his life, and that "he can stand anything." He may lay claim to the possession of what is popularly known as "the constitution of an ox;" but the surgeon's knife is at least one thing he can meet but

indifferently. He will probably not bear an amputation so well as some pale, puny individual of the same age, who is feeble and wasted, and who has been laid up for months with disease of a joint.

The strong man has his mode of life suddenly interrupted. His blood-vessels are full; his viscera have adapted themselves to the exigencies of an active life; his tissue-changes are rapid and extensive, oxygenation is quickly disposing of the great refuse matter which is continually accumulating at the very moment when the tide is abruptly checked. The man finds himself motionless in bed; every circumstance of his life is changed; he has had no time to adapt himself to his altered position, and it is a matter of little wonder that the inflammatory process which has been induced runs riot and is not readily controlled. Circumstances are not improved by his altered mental condition, by the shock of his accident, the horror of the mutilation, the possible miseries of the future.

The subject of joint disease is, on the other hand, acclimatised to bed-life; his diet, his muscular changes, his breathing powers, have all adjusted themselves to the molluscous condition. His viscera are healthy, there is no accumulation of *débris* to be rid of, and possibly even confinement is ceasing to be irksome. To such an individual amputation comes as a relief. He has been wearied of continued pain and inefficient treatment, and the change that amputation brings in his life is agreeable, and opens up the prospects of a new existence. It rids him of a burden that may have become intolerable. The amputation wound in such a man may have healed soundly while the flaps in the case of the robuster patient are still ununited and suppurating.

The great difference in the mortality of amputations for injury and for disease serves to emphasise this point (page 315). It must be distinctly understood, however, that these differences are only partly due to the patient's condition. They perhaps as largely depend upon the circumstances of the amputation, which must of necessity be uncertain in operations for injury where it is difficult to ascertain the limit of the sound tissues.

A small operation upon a healthy man—such an one as will but little, if at all, interfere with his daily mode of life—may be expected to do unusually well; but if the procedure be more extensive, and involve absolute confinement, it is as well that the patient should prepare himself by a few days in bed, and by a modified diet. The preliminary rest of a week in a hospital ward before an operation may have considerable effect upon the issues of the procedure in the case of a labouring man fresh from his work. In few, if any, instances can it be desirable to perform an operation of expediency of any magnitude upon a patient within a few hours of admission into the hospital.

Obesity and Plethora.—The very corpulent are certainly not good subjects for operation. In some of them operations do quite well. These will probably be young persons in whom the disposition to corpulence is hereditary, who are in sound health, and take every reasonable means to prevent increase of weight.

All obese individuals about or beyond middle life are, as a rule, bad subjects for operations, and more especially the men. The excessive corpulence may have been induced by gluttony or drinking habits, or have been encouraged by indolence or disease. These patients often breathe with difficulty, and cannot assume the entirely recumbent position. They soon become helpless; their mere bulk renders it difficult for them to be moved in bed and for dressings to be applied; their skin is frequently unwholesome, and they are not readily kept clean.

The integuments through which the wound is made—in any case involving a surface incision—are thinned, anæmic, and flabby. The edges of the wound come ill together. The immense layer of subcutaneous fat is indifferently supplied with blood, and has probably been damaged during the operation. Portions of this tissue have been broken up and isolated from a blood supply. Indeed, in sponging these wounds before the sutures are inserted, a quantity of such isolated tissue may come away with the sponge. The thickness of the parts involves much strain upon the sutures. If, after the operation, the patient incline towards the affected side, the whole wound region becomes pendulous, drainage

is difficult, and the application of pressure in the dressing of the incision is almost impossible. Under these circumstances, the wound is very apt to break down, sloughing is not uncommon, deep-seated suppuration is comparatively frequent. A low type of inflammation often involves the surrounding skin; the discharges become offensive and ill-conditioned. Such patients often die almost suddenly; others become soon exhausted, or succumb to an intercurrent disease. The most favourable make but a tardy recovery.

Plethora, as a simple condition, does not compromise the success of an operation. Indeed, the "full-blooded" pass through a surgical experience well enough, provided that the plethora depend upon no diseased condition. This ruddy-cheeked, clear-eyed, and firm-limbed individual must, however, be distinguished from the florid and bloated counterfeit so often represented by a brewer's drayman or a jovial innkeeper.

Alcoholism.—A scarcely worse subject for an operation can be found than is provided by the habitual drunkard.

The condition contra-indicates any but the most necessary and urgent procedures, such as amputation for severe crush, herniotomy, and the like. The mortality of these operations among alcoholics is, it is needless to say, enormous.

Many individuals who state that they "do not drink," and who, although perhaps never drunk, are yet always taking a little stimulant in the form of "nips" and an "occasional glass," are often as bad subjects for surgical treatment as are the acknowledged drunkards.

Of the secret drinker the surgeon has to be indeed aware. In his account of the "Calamities of Surgery," Sir James Paget mentions the case of a "person who was a drunkard on the sly, and yet not so much on the sly but that it was well known to his more intimate friends. His habits were not asked after, and one of his fingers was removed because joint disease had spoiled it. He died in a week or ten days, with spreading cellular inflammation, such as was far from unlikely to occur in an habitual drunkard."

Even abstinence from alcohol for a week or two before an operation does not seem to greatly modify the result.

An operation performed upon an habitual or occasional drunkard is apt to be followed by an outburst of delirium tremens, a complication that brings a very greatly increased risk to a patient already in no little danger. It must not be assumed that an operation upon a subject of alcoholism must of necessity turn out badly. The evil result is, however, sufficiently frequent to justify a refusal to perform any but urgent operations, and the occasional fact that grave operation wounds in heavy drinkers may heal kindly and well is rather an illustration of good fortune than of surgical success.

Scrofula and Tuberculosis.—On the whole, it may be said that scrofulous patients stand operations remarkably well, and this especially applies to scrofulous children. In a large proportion of the cases, the operation rids the patient of a long-abiding trouble, and a source of persistent irritation and weakness. It is sometimes surprising to note how a pale, wasted, cachectic-looking child, as wan as a shadow, will improve and gain in flesh and in looks almost directly after such an operation as amputation of the leg for the removal of a wholly carious foot. Some of the best examples—so far as speedy recovery is concerned—of amputation at the hip-joint have been met with among strumous children.

It must be assumed that in these and in other cases there is freedom from serious visceral disease, such as lardaceous degeneration of the liver.

Operations upon the strumous are remarkably affected by their surroundings. The patient requires fresh air and the most favourable hygienic conditions. Results may be obtained at the seaside which can hardly be expected in the crowded wards of a city hospital. In any case—and especially when operating in large towns—the after-treatment of the case should be hastened as far as is possible, and the patient be removed from bed and allowed to get into fresh air as soon as can be managed. By means of suitable splints or retentive apparatus, this can often be effected at quite an early period.

The operation wounds in these patients usually do well at first—often remarkably well. They heal up in large part, then the healing process halts, pus is found to be formed in the depths of the wound, a sinus is apt to persist, or the

scar remains weak, or takes on the character of a strumous ulcer. The area of the wound is occupied by a sodden connective tissue, and from the sinuses that exist, or from beneath the undermined skin, a great quantity of pale, jelly-like granulation tissue can be scraped.

Often enough this disappointment, in what seemed at first to be a speedy healing by first intention, is due to an imperfect removal of the original disease ; but it is not always the case. A like result may follow an amputation through healthy parts.

The scrofulous patient has little power of sound plastic repair. Healing may be rapid, but it is not always substantial. The scar building in the strumous is a little comparable to the work of the "jerry-builder." As Verneuil well says, operations upon the scrofulous abound in "half successes, incomplete results, and unfinished cures."

The success of an operation upon these patients must be judged three months after its performance.

The result can be greatly influenced by the selection of proper cases, by the complete removal of every atom of diseased tissue in the operation area, by taking every step to secure primary healing and to avoid the formation of a sinus, and by placing the patient at as early a period as possible in a fresh atmosphere.

In hospital practice in London, it is most unwise to undertake an operation of any magnitude upon a strumous child if it be known that after the treatment the patient will return to the dingy and noisome slum from which he came.

Upon strumous subjects of middle age, operations must be undertaken more warily. The wounds in these individuals, especially when they involve the diseased area, often do badly, heal but indifferently, and are apt to be associated with inflammatory processes of the lowest type.

I have pointed out elsewhere ("Scrofula and its Gland Diseases") that two independent scrofulous manifestations seldom exist in the same patient at the same time, and that upon the cure of one strumous affection another of a perfectly different character may appear. This sequence has been observed as well after cure by operation as after cure by natural means; and it is possible that in some cases the

impairment of the health incident to the surgical treatment has been favourable to the development of the fresh manifestation.

The occurrence, however, is not common enough, nor is the evil exercised by the operation sufficiently demonstrated, to allow these occasional calamities to influence treatment, except in so far as to emphasise the fact that a condition of feeble health is favourable to the development of the tubercular process.

On the question of operations upon the subjects of *phthisis*, Sir James Paget writes as follows :—"The fever and other accidents that may follow an operation may do special harm to a tuberculous patient. . . . The fear of such a calamity should dissuade you from all operations of mere convenience, and from all measures of what may be called decorative surgery, in phthisical people; but it should not always dissuade you from operations that will cure diseases from which they suffer much, and by which their lives are wasted, as they are by fistula and diseases of bones and joints. In these and the like cases, the main question is, whether the local disease—say, a diseased joint—is weighing on the patient so heavily, or aggravating his phthisis and shortening his life so much, as to justify an operation attended with more than the average risk of life and health.

"In all cases of acute or progressive phthisis, great risk is incurred by almost every operation. The risks of the excitement of many days of feverish disturbance, and of loss of food, and of pain, and all such consequences of operations, are much above the average; to say nothing of the special chances of exciting some pneumonia. I cannot doubt that I have seen patients whose acute phthisis has become more acute, and others in whom the early stages of phthisis were accelerated by the consequences of operations. Therefore, I should follow the rule of never performing any considerable operation, if I could help it, on any person whose phthisis is in quick progress.

"The case is very different with chronic or suspended phthisis. In these it is often advisable to incur the somewhat increased risk of even a large operation, in order to free the patient from the distress and wasting of a considerable local

disease, such as that of a joint; and I should be disposed to say that it is always advisable to cure, if you can, a small disease, such as a fistula. I say if you can, for you will often be disappointed. In the tuberculous, as in the strumous, your wounds will remain for weeks unhealed, and perhaps be unsoundly healed at last. Still, as to the mere question of operating, I have seen so many advantages accrue to patients with chronic phthisis from the removal of limbs with joint disease, that I am disposed to speak strongly as to the general propriety of whatever operations they may reasonably require."

Syphilis.—In the great majority of cases, syphilis does not injuriously affect the course of an operation, and is no bar to such a measure. If the patient be rendered cachectic, or be the subject of visceral disease, he is placed in the same unfavourable category with those who are similarly affected from other causes. Wounds made during the progress of secondary syphilis more often heal well than show any evil tendency; occasionally they become the seat of a transient syphilitic manifestation, and heal indifferently, or break down after a speedy closure. Such an event may occur without the appearance of any distinct syphilitic change in the part. The same may be said of operations performed late in syphilis, or many years after its occurrence. They usually do well. In the minority of the cases, however, primary healing is not secured, or the wound heals, and breaks down again, or remains open, and becomes the seat of a dull, persisting suppuration, or of an ulcer possessed of specific characters. This, perhaps, more often happens when the incision involves tissues which have been previously damaged by syphilitic disease. Thus it comes to pass that plastic operations not infrequently fail in syphilitic persons, especially when performed for the relief of deformities produced by some destructive manifestation of the disease. Such operations should not be lightly undertaken nor carried out until every means, both by general and specific treatment, has been taken to place the patient in the best condition of health.

Rheumatism and Gout have practically no effect upon the immediate future of an operation. The wound heals kindly and well. It is unnecessary to say that an operation should,

if possible, not be performed during an outbreak of either of these conditions. It must be remembered, also, that any of the sequelæ of gout or rheumatism may complicate the issues of an operation. Such are the cardiac changes so often attendant upon the former disease, and the degenerations of the kidneys and other viscera which are apt in course of time to follow upon the latter.

An operation not infrequently determines an attack of gout, but such attack usually has no noteworthy effect upon the progress of the wound. Verneuil remarks that gout sometimes manifests itself at the site of injury by fluxions, with acute pains, which simulate frank inflammation, and which, although of only a temporary character, may suspend or retard the healing process.

Cancer does not render a patient a bad subject for operation. The result of the operation may be modified by other conditions, such as the age and temperament of the subject, and the presence of visceral disease. Cancer, as such, appears to exercise no effect upon the healing process. Indeed, operations for the removal of malignant growths in old and broken-down individuals often do remarkably well.

Anæmia, especially when due to loss of blood, has no special effect upon a surgical wound. The healing may be slow; the patient is perhaps rendered unduly liable to the more serious complications which follow upon wounds, and has little power to meet such misfortunes. It is most important that before an operation of expediency be performed, the anæmic condition should be dealt with by proper treatment.

Leucocythæmia has a most disastrous influence upon operation wounds. Splenectomy, although performed many times in the subjects of leucocythæmia, has been followed by one uniform result—all the patients have died.

Serious, if not fatal, results have followed in less grave procedures, and in the leucocythæmic person even a trivial operation is dangerous. They stand in great peril of hæmorrhage, and become the ready subjects of low forms of inflammation, of cellulitis, and allied conditions.

Hæmophilia forbids a surgical operation of any but the most pressing kind. If the operation proposed be urgent and

required to save life, and if the risk involved by the disease or injury be clearly greater than that which may attend a wound in a "bleeder," it is obvious that the operation should be carried out. Thus, an incision for the relief of strangulated hernia, after every form of treatment has been tried, is justifiable. The subjects of hæmophilia do not always bleed desperately after a wound; perhaps the most certain hæmorrhage will occur after an operation upon the mouth. Still, a member of a "bleeder family," who has nearly bled to death from a slight accidental cut of the lip, may undergo an amputation of the foot with no more than the usual loss of blood.

Scurvy must stand, so far as operations are concerned, in the same position as hæmophilia. Apart from the risk of hæmorrhage which follows an operation performed during an attack of scurvy, there are the further dangers attending a wound which does not heal, which ulcerates and leads to interminable suppuration.

Malaria.—The complex associations of malaria and injury are very clearly dealt with by Verneuil in the following passages:—"Malaria may give rise, at the site of injury, to various complications, such as hæmorrhage, neuralgia, erysipelas, and spasms, complications which assume an intermittent type, and which yield to the employment of quinine.

"The influence of the poison is, however, not always shown by periodical disturbances. Certain wounds may assume a bad appearance, or, at least, remain stationary, until, the cause being suspected, quinine, which acts like a charm, is administered. It is especially in cases of malarial cachexia that are observed that slowness and insufficiency of repair, which end in serious diffuse inflammations, or even in gangrene, and which are not always subdued by antiperiodic remedies.

"The operation may occur under one of the following circumstances:—

"1. In a patient actually affected by intermittent fever. In this case the wound, especially if it be followed by hæmorrhage, rapidly and markedly aggravates the disease.

"2. In a patient who has previously been the subject of ague, but who appears to have entirely recovered. The

wound, even when slight, may induce a fresh onset of ague; although the recovery from the last attack of fever was five, ten, fifteen, or even more years ago. On the other hand, the wound itself may become the seat of some local intermittent complications, the patient being free from the usual manifestations of the disease.

"3. In a patient who has never had intermittent fever, who is living in a healthy country, but who has formerly resided in a malarial district. The wound in such cases may apparently give rise to intermittent fever or to intermittent complications. It is clear that the injury, not being able of itself to produce a true intoxication, has merely provoked the explosion of a hitherto latent disease. These latter cases are not very rare, and are especially observed in large cities and in the healthiest regions."

Acute Diseases, Erysipelas, and Inflammation.—It is needless to say that no operation, except such as is so urgent as to be necessary to save life, should be performed during the progress of any acute disease, such as pneumonia, an eruptive fever, and the like.

The same may be said of erysipelas. Incisions have to be made in the course of that disease to relieve tension and to evacuate pus, but they cannot rank as operative measures. If an amputation is rendered necessary in a subject of erysipelas, the less danger would attend the postponement of the operation until the acute period of the fever had passed.

It is most important to avoid, when possible, any operation upon inflamed parts. This applies as well to so small an operation as the removal of a pile as to the excision of a large tumour. With operations in the present sense are not classed such surgical measures as are employed for the relief of inflammation.

Sir James Paget gives a striking example of departure from this rule. "A man came to me," he writes, "in the out-patient's room, with a cyst on the front of his abdomen, acutely inflamed. I removed it at once. Three or four days afterwards he was admitted with inflammation of the cellular tissue and infiltration of putrid matter under the skin; and that was followed by phlebitis, and that by pyæmia, and that by death."

It may be here remarked, also, that a good and fine cicatrix cannot be expected if the margins of the wound are formed of tissues which were inflamed when the incision was made. This is well illustrated by operations upon the neck for gland disease, in which it is a point that the resulting scar should be as insignificant as possible.

Affections of the Nervous System.—The mental state of a healthy patient, as expressed by the terms "nervous," "neurotic," "excitable," "apathetic," has little definite effect upon the result of an operation. The very nervous individual, who approaches the operation with bated breath, who discusses it with a fluttering vivacity, and is haunted by exaggerated forebodings, usually does well enough. After the operation is over, her imagination probably enters upon a new field; she conceives and prophesies a speedy recovery, and often assumes the *rôle* of the unusually hopeful and courageous patient.

The least favourable frame of mind is that marked by gloom and utter apathy, and by a morbid, stoical indifference, difficult to dispose of. It is illustrated by the dull-faced woman, whose conversation smacks of "Meditations among the Tombs;" and by the sullen man, who meets a cheery account of the hopeful prospects of his operation by the remark that "he is ready to go."

Possibly the most favourable nerve conditions are met with among healthy young men, who sleep well, take whatever happens as a matter of course, make few inquiries, and meet all circumstances in the spirit of Mark Tapley.

Operations upon *hysterical* or *epileptic* patients are apt to be complicated in their after-treatment by outbreaks of the nerve affection. While attacks of both hysteria and epilepsy are clearly often induced by an operation, on the other hand a precisely opposite effect may follow the surgical measure.

The *insane* bear operations unusually well, provided that certain conditions are present. They must be in sound health, and amenable to treatment, and of cleanly habits The regular life of an asylum is conducive to a state of health very well adapted to meet the strain of an operation; and the absence of mental anxiety in the patient is another favourable feature. In many subjects of chronic mania, of

melancholia, and of dementia, the general health is quite broken down, and, as a consequence, they become unfit subjects for any operative treatment. In those of the insane, also, who are violent, restless, mischievous, or of very dirty habits, the success of the operation may be so far frustrated by the patient that its performance becomes a matter of question.

In not a few instances, insanity appears to have been induced by operation. The patients are mostly women, and the operation, for the most part, one concerning the breast or pelvic organs. The occurrence of this unfortunate circumstance is neither frequent enough nor sufficiently well defined to influence a surgeon in the performance of a necessary operation.

It is needless to point out that operations performed upon paralysed limbs or upon the lower extremities of the subjects of locomotor ataxia can scarcely be expected to turn out well. The gloomiest forebodings are often not realised, but on such individuals operations should not be performed except on compulsion.

Diabetes offers an almost positive bar to any kind of operation. A wound in a diabetic subject will probably not heal, while the tissues appear to offer the most favourable soil for the development of putrefactive bacteria. The wound gapes, becomes foul, suppurates, and sloughs. Gangrene very readily follows an injury in diabetics, and they show a terrible proneness to a low form of erysipelas and of spreading cellulitis. Diabetic gangrene of a limb is scarcely within the scope of surgical measures. An amputation in such a condition is almost invariably fatal.

Even when the diabetes has been actively treated, and the patient's condition has much improved, an operation is still almost as unpromising. After the injury the amount of sugar in the urine increases again, and the result of months of careful treatment is rendered of little avail.

Visceral Disease.—1. *Heart Disease and Atheroma.*—In the matter of heart affections, it may be said that the patient whose heart is feeble, or fatty, or embarrassed by valvular disease, is exposed to extraordinary risk from the shock of an operation, but apart from this, heart disease, if it has induced no widespreading tissue change, appears to add little to the

danger of the undertaking. On the other hand, as Verneuil points out, valvular lesions and degeneration of the muscular tissue of the heart may, by changing the conditions of the entire circulation, modify the composition of the blood, cause impairment of the viscera, alter the tissues, and bring about a condition very unfavourable to the healing process. Such patients show a disposition to passive hæmorrhages—difficult to check, together with œdema of the wounded region—to patches of erythema, to erysipelas, and even to gangrene. There is a local atony which indefinitely delays healing and converts the wound into an ulcer.

Operations are often performed upon limbs the arteries of which are affected by atheroma. It is surprising how well ligatures maintain a hold upon such vessels, and how well they remain closed. The risk that would appear to be most pressing, that of secondary hæmorrhage, is in actual practice seldom encountered. That wounds in such patients are more liable to secondary bleedings than are wounds involving parts supplied by normal arteries is true, but the occurrence is not frequent. The real risks in these cases are from gangrene, from sloughing of the flaps of an amputation, or the breaking down of the simplest incision, and from diffuse inflammations of a low type.

2. *Lung Disease.*—The relation of phthisis to the results of an operation has been already considered. Any chronic lung affection, such as chronic bronchitis, usually indicates impaired health, and offers difficulties in the after-treatment on account of the embarrassed breathing, the disturbance of parts produced by coughing, and the imperfect oxygenation of the blood. Operations on such individuals can hardly be expected to follow a quite even course.

3. *Affections of the Alimentary Canal.*—In the matter of affections of the alimentary canal there is little to be said. The effect that any disease of the stomach or intestines may have upon an operation is to be measured by the effect it has upon the general health. The subject of chronic dyspepsia can hardly be well nourished, and the subject of habitual constipation is burdened with a trouble which an operation serves to complicate. It is unnecessary to state that an operation of any kind should be avoided during the

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course of diarrhœa or dysentery, and should not be undertaken until the patient has well recovered from the trouble.

4. *Diseases of the Liver.*—Affections of the liver have a very injurious influence upon operations; an influence which is peculiar and pronounced, and a frequent cause of death in surgical wards.

Even the slighter forms of hepatic trouble serve to compromise the future of an operation. "You should be cautious," writes Sir James Paget, "in operations upon those whose biliary secretions are habitually unhealthy; those who have been often jaundiced; or those who bear that sallow, dusky complexion, with dry skin, and dilated small blood-vessels of the face, and sallow, blood-shot conjunctiva, which commonly tells of what is supposed to be an 'inactive liver.' Many of this last class are not temperate; many are sedentary and indolent; many suffer habitually from hæmorrhoids; probably all have some abdominal plethora; probably, in all, their digestive organs act as ill as their skins do. But, whatever we may guess to be the special defect of these organs, you need not doubt that operations upon those who have them are attended with more than the average risk; and that when you are obliged to operate, you must do so with more than ordinary care and caution."

The more defined diseases of the liver have a definite ill effect upon surgical wounds. These are cirrhosis of the liver and the conditions of fatty or amyloid degeneration. Advanced forms of these affections offer an almost absolute bar to operation. Operations performed in the earlier stages of the disease will certainly be injuriously affected. The subject of cirrhosis is probably a drunkard; the subject of amyloid degeneration, the victim of long-continued suppuration.

The risks these patients run are numerous: some succumb to shock, others die of exhaustion. In all there is a great risk of secondary hæmorrhage, and a probability that the wound will not heal, but that it will slough and suppurate, and become the seat of spreading inflammation of a low type. Pyæmia is, or was, unduly common in these patients.

No question is more difficult to decide than that which

concerns the period in the progress of lardaceous disease of the liver beyond which it is practically unjustifiable to operate.

In the advanced stages of the disease a serious operation is certainly not justifiable. In the earlier periods, an operation, such as an amputation, may be performed with ultimate admirable success, for it not only rids the patient of his trouble—probably a suppurating joint, with adjacent necrosed bone—but it removes the cause of the visceral complication.

5. *Kidney Disease.*—It may be safely said that the results of operations are more powerfully influenced by diseases of the kidneys than by a corresponding disease of any other organ. An operation upon the subject of Bright's disease, or of surgical kidney, is a desperate matter. A patient may look fairly healthy, may appear well nourished, may be temperate and living a most regular life, and the operation may be but a trifling one, yet the complication of albuminuria renders the surgical procedure one of the most serious and the most hazardous. Many an elderly man has died almost suddenly from the effects of rough catheterisation, and it has been found after death that he was the subject of an unsuspected pyelitis.

Quite slight operations, of no urgency, such as that for the relief of Dupuytren's contraction of the palmar fascia, have placed the subjects of Bright's disease in great danger of death.

In no case should an operation on an adult be undertaken without a preliminary examination of the urine.

Before performing an abdominal operation, it should be a matter of routine that the urine be examined daily for not less than one week. Almost every surgeon must have met with instances in which the neglect of this precaution has led to calamitous results.

It is impossible to define the particular power for evil each individual affection of the kidney has upon a surgeon's work. It is sufficient to know that the existence of pus or albumen in the urine places a patient within the very narrowest sphere of operative possibilities. It is true that in some instances—as in a form of albuminuria met with in

connection with large abdominal tumours—the existence of the albumen is no bar to an operation; it is true, also, that patients with Bright's disease have now and then recovered admirably from large operations. The fact remains that organic disease of the kidney is one of the most serious complications with which the operator can be concerned.

The subjects of kidney disease exhibit nearly the same evil tendencies after operation as have been alluded to in dealing with hepatic troubles. They are exposed to the additional risk of death from suppression of urine and uræmia. Such patients often die of exhaustion many days, or even a week or more, after the operation. They are especially prone to all the evils incident to wounds. Primary healing can never be depended upon.

A plastic operation is unjustifiable in a subject of kidney disease; the operation wound is liable to break down, to suppurate, and be the seat of secondary hæmorrhage, of erysipelas, of a foul cellulitis, and of gangrene. When pyæmia was common in hospital wards, the subject of kidney disease became its readiest victim. Surgeons have learnt how to ward off pyæmia, but they have yet to learn how to meet the terrible complication of Bright's disease.

2.—THE PREPARATION OF THE PATIENT.

The Period before the Operation.—It will be evident, from what has been already written, that the most thorough examination possible of the patient should be made before an operation is undertaken.

To carry this out, it is well that the individual should be under observation for some little time before he appears in the operating room.

In the case of those who have been long confined to bed, it is obvious that the sooner they are relieved the better.

On the other hand, in the matter of operations of expediency upon patients who may be termed healthy, it is well that they should pass through a period of rest before the operation is performed. Operations hurriedly undertaken are often perilous, and are not infrequently regretted. It has been already pointed out (page 6) that the condition of

active, robust health is not the best adapted to meet the circumstances of surgery.

In hospital practice it is never wise to operate upon a man who comes straight to the wards from some active out-door work, who is robust, and has been living heartily, and who has still the vigorous throb of exercise in his blood and in his limbs. To perform upon such a patient such an operation as that involved in the radical cure of hernia, is to expose him to needless and reckless risk. The practice is frequent, for the operation has been previously arranged, and the man does not want to lose even a few hours' work.

Such a patient is placed in an infinitely better condition by a few days' rest in a hospital ward. He here becomes accustomed to his surroundings; he has time to be rid of the refuse matter in his tissues, which can no longer be cast off by muscular exertion; his hearty appetite is enabled to adapt itself to his present requirements; the excreta can be dealt with; and time is allowed (and it is needed in some hospital patients) to make clean the skin.

To all the organs, to the still strongly-beating heart, and to the over-worked muscles, there is allowed a period of repose. When the operation day arrives, the patient has become acclimatised, strict confinement to bed and a limited diet do not involve so very sudden a change, he has adjusted himself to his new environment, and the ordeal is met after a period of physiological rest.

The same applies equally to surgery in private life. Many a surgeon has regretted an operation, performed on the spur of the moment, in his own consulting room, and the patient has lived to place a peculiar construction upon the operator's definition of a "mere trifle" or a "mere prick."

Many small operations would do infinitely better if the patient would consent to the preliminary of a few days' rest. This is conspicuous often in operations upon piles, when the subject persists in absorbing himself with his work up to the time of the operation. Often a business man will overwork himself desperately before his operation in order that his affairs might not suffer in his absence.

What is worth doing at all is worth doing well, and not a

few operations, the performance and recovery from which have to be compressed within a few hurried days, had better not have been performed at all.

Diet.—The practice of starving a patient before an operation is undoubtedly unwise. The amount of the food should be suited to the condition of an individual who is inert and within doors. It should be nutritious, but small in bulk, and not of a character to leave much *débris* in the intestine. Entire abstinence from alcohol for a week or more before an operation might prove very judicious in not a few instances. The patient who "keeps himself up" by spirits before an operation is preparing for himself a sore down-going after the event is over.

The Bowels.—The bowels should be well opened on the eve of the operation; and this is best effected by an aperient overnight and an enema in the morning.

Cleanliness.—Care should be taken that the patient's body is clean. A warm bath on the night before the operation is desirable whenever possible, and a source of comfort to the patient.

The part to be operated upon should be especially cleansed. The skin should be well rubbed, or even scrubbed, with soap and water, and may be afterwards more thoroughly purified by being covered for some hours with a towel soaked in carbolic lotion.

The shaving off of the axillary or pubic hair—when an operation concerns those regions—might be postponed until the patient is being anæsthetised.

Clothing.—The body should be well and warmly clad during an operation. Not a little of the shock that often follows a long operation may be due to the fact that the patient has been lying nearly naked upon a table, for an hour or more, possibly in a cold room, and exposed to the further chilling action of wet applications. This precaution applies especially to old persons and to the winter time. So long as the part to be dealt with is well exposed, the rest of the body cannot be too well protected, and liberal use should be made of blankets, warm woollen stockings, woollen jerseys, jackets, and the like.

The night-dress to be worn after the operation should be

divided down the back, so that it may be removed without disturbing the patient. The form of flannel jacket called by nurses a "nightingale" is very useful, especially for patients who can sit up in bed.

In the case of women with long hair, the various coils and twists should be undone, the whole hair parted behind in the median line and disposed of in two simple lateral plaits. The hair is thus kept out of the way—should the operation concern the head and neck—and after the operation the head can rest comfortably upon the natural scalp, and not upon a complicated mound of wisps of hair, hair-pins, and other foreign substances.

The Hour for the Operation.—The most convenient time for an operation is the early morning, say between eight and ten a.m. As the patient should have no food for five hours before he is anæsthetised, this appointment involves the omission of no meal but breakfast. If he has slept well, there is little time between his sleep and the surgeon's coming in which to ruminate and to foster an alarm. Should any serious complication occur within a few hours of the operation, it will be daylight, and prompt assistance will probably be at hand.

The above observations apply to the preparing of a patient for an operation of some magnitude. They apply in proportionate degree to procedures of lesser gravity. For certain measures special preparations have to be made. These are described in the sections which deal with them.

CHAPTER II.

THE OPERATOR.

THE surgeon, according to the oft-quoted axiom of Celsus, should be young. By this it is to be inferred that he should be possessed of the muscular strength, the courage, the sureness of hand and the keenness of eye, which are assumed to be the qualities of youth.

Operative surgery is a *handicraft*, and the accomplished operator must lay claim to be considered a skilled handicraftsman. Like other and simpler handicrafts, much in the attainment of success depends upon natural aptitude and physical qualification; but still more depends upon culture and patient practice. A well-matured and well-balanced judgment guides the hand of him who shows most skill; he may do well who is bold, but he will do better who has precise knowledge. The surest sense of confidence rests with the operator who knows accurately what he intends to do, and how to do it. The least success follows the hand of the man who retains throughout an operation a speculative spirit, who depends largely upon his imagination for conditions, and upon the fortune of events for results. A shakiness of the hand may be some bar to the success of an operation, but he of a shaky mind is hopeless. In the handling of a sharp instrument in connection with the human body a confusion of the intellect is worse than chorea.

The actual manipulative part of surgery requires no very great skill, and many an artisan shows infinitely more adeptness in his daily work. A wood engraver would probably soon find as little difficulty in baring the carotid artery as a stone carver would find in performing osteotomy.

It is in the mental processes involved in an operation that not a few fail. There is some lack in the precision, the strained attention, the art to meet any possibility, and the

capacity for forming a ready judgment, which must follow each movement of the surgeon's knife.

Some of the most incredible examples of surgical blundering, such as the fashioning of flaps in such a way as to amputate the trunk from the limb, and the opening of the stomach in mistake for the colon in performing lumbar colotomy, are calamities due to mental rather than to physical defects.

The mere handicraftsmanship of surgery depends, as has been already said, not only upon natural physical endowments, but also upon careful practice and education. Some men are born with steady, dexterous fingers and precise and quick-moving muscles; others overcome, with more or less success, a congenital and obstinate clumsiness.

Every pains should be taken to cultivate what may be termed *a surgical hand*. A shaky hand may be born with its possessor, and may remain unaffected by any attempts to amend it. This important defect may also be developed by irregular modes of living, by the moderate use of alcohol, and by smoking. The effect of tobacco is obvious enough in most instances, although its influence may be very transient.

The full use of the larger muscles as developed by vigorous athletic exercises adds distinctly to the steadiness of the hand, and of his general muscular development an operator should be most careful. Athletic exercises, involving the upper limbs, such as fencing, rowing, and practice in a gymnasium, certainly render the hand for some hours after such exercise unsteady, although after a longer period of rest precision in the action of the smaller muscles is with equal certainty improved. In connection with this point, it is needless to say that violent exertion on the part of the operator is not wise immediately before an operation. A surgeon who is careful of the manner in which his scalpel is held should not carry a heavy bag to the scene of his labours, nor should he take part in such muscular exertions as are needed to move operating tables or beds, or to lift a heavy patient. The vigorous efforts which may be necessary to restrain the violence of a patient under chloroform are apt to render the arms of those so engaged very tremulous.

The action of the palmar muscles can be very admirably

developed by such occupations for a leisure hour as etching on copper, sketching, or wood carving.

A knowledge of *anatomy* is essential to the operating surgeon. Such knowledge as is needed, however, is not to be obtained from books alone, or even from books in preponderating degree. It must be such "anatomy" as is to be acquired by long work in the dissecting-room, and it may not be too much to say that he who would deliberately adopt the career of an operating surgeon should have served for some years the dreary apprenticeship involved by the duties of a demonstrator of anatomy.

Such work teaches, not only the position and relation of parts, but it, and it alone, can instil into the mind and the fingers a proper *appreciation of tissues*, and the knowledge of what may be termed the *anatomy of the individual*. A surgeon may know well the origin, insertion, and relations of the parietal muscles of the abdomen, but he who has dissected and demonstrated the lumbar region in "subjects" of all kinds, many times over, has also a knowledge of the depth, the thickness, the appearance, and the disposition of the tissues, not as they lie in an abstract body, but as they may be expected to be found in individuals of different types.

Moreover, the work of dissection affords the most excellent training in the handicraftsmanship of the future operator.

Precision of knowledge, precision in judgment, precision of hand, are all needed in a surgical operation. They are the foundation of the coolness and the *sang-froid* with which a surgeon is presumed to be possessed, and it is to their absence that can usually be ascribed that condition of mind known as "surgical delirium."

He who is about to undertake an operation should know precisely what he intends to do, and should then proceed to do it. He should have estimated probabilities, and be quite aware of his mode of dealing with them.

The individual who plunges into an operation with an uncertainty he would condemn in the pursuit of an ordinary business undertaking, and who discards anatomical precision for the old maxim "cut and tie," is likely to reap the reward of his labours.

The surgeon's *precision* should apply to every detail of the operation and its surroundings. He should select and arrange and examine his instruments with the greatest care; should consider himself responsible for the minutest detail in the needed arrangements; and should have a proper respect for the magnitude of small things.

The introduction of anæsthetics has very greatly altered the circumstances of operative surgery, as it has transformed the surroundings of the operation table.

It is no longer a point of primary importance that a stone should be extracted in a few seconds, or a limb removed in a limited number of minutes. A pupil with a watch in his hand no longer stands beside the struggling and shrieking patient to take "the time." The days of the so-called "brilliant" surgeon are over. Brilliancy, as now associated with operations, will probably concern the reckless manipulations of an irresponsible hand or the fortunate thrusts of the overbold. It belongs to the surgical "free lance," and is associated with many happy results, and with many more which are lamentable.

The operating theatre of a large hospital, and the presence of an audience of enthusiastic and marvel-loving students, offer a great temptation for the display of theatrical effect, and encourage a disregard for other than immediate results.

The time is even now not long past when a surgeon would "whip off" a leg or remove a stone with something of the fever and *éclat* of a conjurer who draws an unexpected rabbit from his sleeve.

The *assistants* at an operation have an exceedingly important office to fill, and their capacity for their work must necessarily vary. It is a part of an operator's duty to see that each assistant is fully informed of what he has to do, and, if possible, of the manner of his doing it. An unsuccessful operation is often attended by much abuse of the assistants, and by very severe criticisms of their manipulative powers. Such condemnation may be just, or may only serve to illustrate the proverb that "a bad workman complains of his tools." It is during the most perplexing stages of an operation, and when things are going ill, that the indifferent operator finds that knives will not cut, that forceps will not

hold, and that the clumsiness of assistants is beyond the limits of human belief.

In the matter of *dress*, the operator should be "in his shirt-sleeves," with his arms bare, and clothed from his collar to his feet in a simple macintosh apron. The practice of wearing an ancient and discarded frock-coat, which repeated operations have rendered stiff with blood, is not consistent with the rudiments of antiseptic surgery. If the surgeon must wear a coat, let it be an entirely new one.

Sleeves of macintosh, or of any other material, are objectionable, clumsy, and in the way.

CHAPTER III.

The Operating-Room.

The Room.—Of the operating theatres and operating wards of hospitals it is not necessary to speak. It must be assumed that they have been constructed upon an accepted plan, and are equipped to the satisfaction of those who are responsible for the treatment carried out in them.

On the other hand, no little care has to be exercised in selecting and preparing a room in a private house for an operation of importance.

It is, in the first place, essential that the house be in a perfectly *sanitary condition*, and as it appears to be an article of the householder's faith that the hygienic state of his or her premises is exceptionally perfect, it is well that the building should be examined by a skilled person without the residential bias.

On the night before the operation the patient should sleep in a room other than that in which the operation is to be performed. The operating-room can then be prepared at leisure, and without the patient's direct knowledge. It is in this room that the patient should remain during the after-treatment. A second bed will probably be required for a nurse. As Mr. Doran well puts it, " the apartment, speaking in general terms, should be large enough for two people to live and sleep in for several weeks, according to current authorities in hygiene."

The room should be made as nearly like a hospital ward as possible. The carpet and all unnecessary hangings and curtains should be removed. It should be bared of all but absolutely essential furniture. The walls should be brushed down and the floor scrubbed, and the room may be well ventilated on the previous day by open windows and a large fire.

The practice of allowing a carbolic spray to be at work

in the room for some hours before the operation is commendable, especially in the crowded houses of a large town.

The room should be quiet, light, and well ventilated, and is pleasanter if its windows look towards the south. It should not be near a water-closet. An open fireplace is most desirable, and the less gas burnt in the room the better. It should be ascertained that the windows open readily. The table should stand upon a square of drugget, for a carpetless polished floor is apt to be dangerously slippery.

The *temperature* of the room during and after the operation should be kept at about 60° to 65°, and should not be allowed to fluctuate.

The Patient's Bed.—The patient's bed should be a narrow, simple, iron bedstead, with a woven spring body, upon which is placed a horsehair mattress. There should be no rail on either side, and but a low one at the head or foot. The bed should be so located in the room that the patient will be accessible from all sides, and the wound be dressed with ease.

It is usually most convenient that the bed should stand in the centre of the room—probably in the place occupied by the operating table—and be so arranged that the head is towards the light, that is to say, as the individual lies in bed the light will be behind him.

A bed in a corner is always inconvenient, and may in a case of sudden secondary hæmorrhage be a source of danger, the patient being accessible from one side only.

To allow a heavy patient, after a serious operation, to return to a large wide bedstead, covered by a voluminous feather mattress, into the centre of which the helpless individual sinks, is to place him in a position of some peril.

After many operations a bed-cradle will be required. In some cases a "bed pulley" may be conveniently affixed to the joist of the ceiling over the head of the patient's bed.

Accessories.—The other accessories are a large table for the basins and one or more small and light tables for the instruments. The instrument table should be on wheels, so as to be readily moved when required. A large vessel in which to first rinse the sponges as they are handed back, soaked with blood, etc., to the nurse, is desirable, and for this a china foot-bath answers admirably. Receptacles are needed for the

dirty water, and possibly for such evacuations as ascitic fluid or the contents of an ovarian cyst.

A liberal supply of hot water should be at hand, and a suitable provision of pillows, towels, and macintosh sheets, together with the usual nursing accessories. In Mr. Mayo Robson's valuable little book, "A Guide to the Instruments and Appliances required in Various Operations," is a detailed list of the articles actually needed both in the operating-room and the patient's bed-room. Another valuable pamphlet is Dr. Keen's on "The Organization of an Operation."

The Operating Table.—The table employed should be simple, strong, and steady. It is essential that it should be narrow, and of a height convenient to the individual operating. A table with the following measurements will be found convenient: length, 5 to 6 feet; width, 2 feet; height, 33 inches. It should be covered by either a thin, firm horsehair mattress, or by a large and neatly-folded blanket. The latter is the more convenient in operations performed in private houses.

The plan of having two small tables placed in the form of the letter T is decidedly inconvenient. It should be remembered that the table may need to be moved during the operation. For example, in the removal of the tongue, with preliminary ligation of the lingual arteries in the neck, it is not often that the table can be so placed that the light falls equally well upon both sides of the neck. As a good light is very essential for this procedure, the table may have to be placed in one position while the left artery is being secured, and in another when the right is dealt with. A slender, unsteady table may prove a source of actual danger. I have seen a table give way entirely while the struggles of the patient were being restrained during the early stages of anæsthetisation.

The crazy contrivances and makeshifts which the patient's friends sometimes consider to be ingenious substitutes for a proper table are to be distinctly avoided. I have a recollection of one altar-like construction, made of four boxes and a small chest of drawers, upon which was recumbent a heavy man, prepared for an excision of a part of the lower jaw.

The best operating table with which I am acquainted is that designed by Professor William Rose, of King's College,

and manufactured by Roskilly. It is in use at many of the metropolitan hospitals. It is strong, but light, and is in every way remarkably convenient.

The table is very steady, but by the action of a simple lever is at once raised upon wheels, and can then be moved about readily while the patient is lying upon it.

The head and shoulders can be raised to any angle by a simple screw mechanism. By another contrivance, the inclination of the whole trunk can be altered in a moment. By an equally convenient apparatus, both lower limbs can be flexed at the knee and hip joints. The "leg pieces" of the table can be placed at any angle, or can be removed, as would be necessary in amputation of the lower limb. While the patient is in the lithotomy position, the buttocks can be elevated or lowered as required, and with the utmost readiness.

Although capable of manifold adjustments, the table cannot be said to be complicated, and so far as strength is concerned it has well stood the test of time.

The Arrangement of the Tables, etc.—The operating table

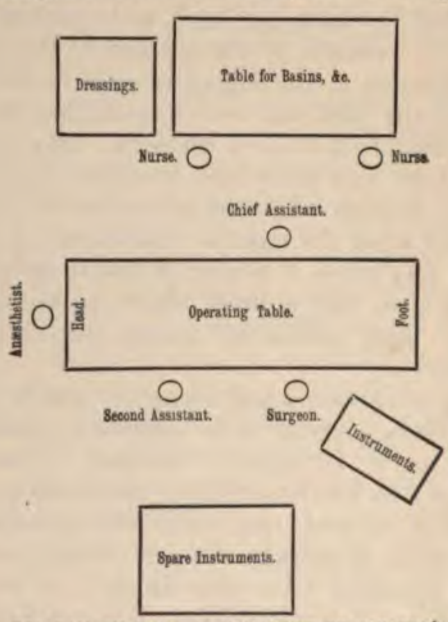

FIG. 1.—DIAGRAM SHOWING ARRANGEMENT OF SURGEON'S TABLES.

should be placed in the best attainable light, and, in the case of most operations, with the patient's feet towards the windows. If there be two windows near together in the same wall of the room, the table may be so placed as to be at right angles to the wall, and to have its foot opposite the space between the two sources of light. There should be sufficient room on all sides of the table to allow an individual to pass freely.

The general disposal of the tables, and of the surgeon and his assistants, is illustrated in the diagram (Fig. 1), which may be considered to relate to such an operation as the radical cure of hernia or the removal of a tumour from the thigh.

The anæsthetist stands at the head of the table, and the operator on the patient's right. Close to the surgeon's right hand is a light table for the necessary instruments.

A larger table for accessory and spare instruments, and for such apparatus as the thermo-cautery, etc., may be placed at a distance behind the operator.

The chief assistant stands on the left side of the table, opposite the surgeon. It is by this assistant that the sponging is done and the hæmorrhage attended to.

Behind this assistant, and entirely to the left, is a large table for the basins needed for the sponges, and for receivers, jars of lotion, etc., and at this table the two nurses are placed.

A smaller table may stand close to the larger one to take the dressings necessary for the case

A second assistant may place himself to the operator's left and upon the right-hand side of the operating table.

CHAPTER IV.

THE INSTRUMENTS AND ACCESSORIES.

THE operator should attend personally to the selection and care of all instruments, and to the minutest matters which concern them.

They should be in perfect condition, and above all things *clean.* Dissecting forceps and pressure forceps are often found with the teeth clogged with the blood from the last operation, or with the greasy black compound with which they have been last cleaned at the instrument-maker's. Trocars, directors, and probes need very careful cleaning, and, although the blade of a knife may be brilliant, its rough handle may be filthy.

An opportunity is sometimes afforded of inspecting the instruments in a little-used pocket case, and their condition is occasionally open to unpleasant criticism.

Ingenious instruments which fold up into a small compass, or which combine many functions, are usually to be avoided.

In the *selection of instruments*, each manipulator must exercise his own taste, and found his choice upon his habit of hand. It is improbable that twenty men would select the same pen or pen-holder out of a collection of twenty samples, but they might all write equally well.

There is no doubt but that the fewer the implements to which a surgeon accustoms himself, and the simpler they are, the better. As has been already said, the surgeon's work is a handicraft. He should depend more upon his fingers than upon his tool. He who is really expert with one instrument has an advantage over him who is indifferently familiar with many.

The best work is done with the simplest implements. A surgeon who is dependent upon a special instrument for this and a special instrument for that, is a poor handicraftsman.

He is servilely subject to his special forceps and his particular knives and needles for a particular operation. An intending subject for operation may well measure the depth of his sigh, at the sight of the surgeon, by the size of the operator's instrument bag.

Some of the least progressive periods in the development of the surgeon's art have been marked by the prolific production of instruments. With few exceptions, complex apparatus and appliances which are credited with being ingenious, or labour-saving, or automatic, are bad.

A great multitude of the instruments which figure in the makers' catalogues are evidences of incompetence, and of a lack of dexterity which prevented the inventor from making full use of his hands.

On turning over the pages of such catalogues, one is struck by the circumstance that among the very numerous names of designers of instruments there are but very few belonging to surgeons who are or have been eminent as first-class operators. It is true, moreover, that among what may be termed modern new instruments, the chief of those which have come into immediate and general use are accredited to famous operators. With such may be named the bone forceps and lion forceps of Fergusson, Liston's amputating knives, Syme's knives, and the ovarian trocar and pressure forceps of Sir Spencer Wells.

A great deal can be done in operative surgery with a scalpel and a pair of dissecting forceps, and indeed there is but comparatively little that cannot in some way be accomplished with those instruments.

A brief notice is here given of the simplest, most general, and most essential instruments. The special instruments are considered in the chapters dealing with the procedures with which they are concerned.

The Scalpel should be light, and should have a handle of good length, which should be thin and quite smooth.

A length of four inches for the handle, and a width of from three-eighths to half an inch, are convenient. A shorter handle does not rest properly in the hand; it is like a too short pen-holder or paint-brush. A longer handle is unnecessary.

The breadth and width of the handle may possibly vary a little with the size of the blade, but the length should not vary. A scalpel with a small and very fine blade does not need a handle proportionately reduced. Indeed, the most excellent small scalpels are those which had originally blades of good size, but which have been reduced to slender and short proportions by repeated grinding. Although small in the blade, they still retain the original handle.

The blade should be what instrument-makers call "middle-pointed"—*i.e.*, the point should lie on the long axis of the steel (Fig. 2 A).

A "back-pointed" blade is not well suited for the scalpel. It answers for larger knives, which are broad in the blade, and are required to make large and free incisions; for example, the handiest form of post-mortem knife and of cartilage knife is back-pointed.

Very fine scalpels are a grievous delusion. If a beginner is about to undertake an operation involving a "fine" dissection, he will probably seek a knife with a very fine point. Such a knife is depicted in Fig. 2, B, and is copied from a catalogue of instruments. It is a useless tool; it is, indeed, a needle, not a knife. A surgeon who once attempts to perform a fine plastic operation with such an instrument will probably discard the knife for ever.

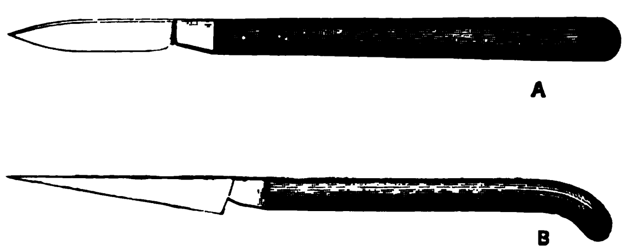

Fig. 2.—(A) GOOD SCALPEL; (B) BAD SCALPEL. (From a modern catalogue of instruments.)

A small scalpel, with a good blade and a "middle point," and with such an outline as is depicted in Fig. 2, A, is the best instrument for the finest work the operator can be called upon to perform. The very fine back-pointed knife will scratch, but it will not cut.

The back of a scalpel should be blunt up to the very point. Double-edged knives are purposeless—in any ordinary operation—and the surgeon's fingers are apt to be cut by them.

The ordinary forms of *bistoury* have handles somewhat more substantial than those of scalpels, and they are convenient if a little roughened, but the length of the handle need not be much in excess of that of the scalpel.

A straight probe-pointed bistoury, with a blade two and a half inches in length, is the most useful instrument of the class.

Dissecting Forceps should have a good spring, should be

Fig. 3.—STOUT DISSECTING FORCEPS.

short, and should not be too narrow at the points. Four and a quarter inches is a very convenient length. Dissecting forceps are not uncommonly too lightly and too frailly made to be serviceable. The strength of the spring must depend upon individual taste. For all ordinary purposes a good broad point is desirable; it enables the surgeon to obtain a firm grasp of the tissues, and at the same time does not prevent a very small fragment of tissue from being picked up (Fig. 3).

Fig. 4.—SPENCER WELLS'S ARTERY FORCEPS.

Artery Forceps.—The pressure forceps of Sir Spencer Wells are simply invaluable, and have proved to be one of the most important recent additions to the surgeon's armamentarium.

The best instruments are those of the original pattern (Fig. 4), and there is little or nothing to be said in favour of the various "modifications" and "improved forms."

Of the different varieties of artery forceps, the best is that known as Wakley's (Fig. 5). They pick up the vessel

Fig. 5.—WAKLEY'S ARTERY FORCEPS.

cleanly, retain a good hold, and render the application of the ligature efficient and easy.

For twisting an artery no especial apparatus is required. Wells's pressure forceps form the simplest torsion forceps, and may take the place of many of the complicated instruments known by the latter name.

Retractors.—An assistant's fingers form, in a large proportion of all operations, the best retractors.

In certain operations, and especially in the case of deep wounds, some special means of retracting the soft parts or the skin is required.

In a following section is described (page 55) the method of retracting the skin in many small operations—such as the removal of a superficial tumour or the radical cure of varicocele by means of ligatures. This method leaves the area of the operation wound quite free.

To draw special tissues aside, such as a tendon, a nerve, or a vein, blunt hooks answer admirably. They take up little room, and encroach but little upon the area of the operation. They should be long enough and large enough for the purpose, and be firmly secured in handles.

As simple wound retractors, the handiest and the most efficient are those of Farabeuf (Fig. 7), which are made in many sizes. The little turn at the end of the metal gives

them an excellent hold of the tissues. A very convenient

Fig. 6.—FARABEUF'S MODIFICATION OF LANGENBECK'S RETRACTOR.

instrument also is Farabeuf's modification of Langenbeck's retractor, shown in Fig. 6.

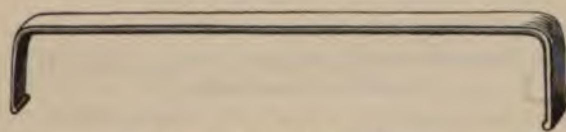

Fig. 7.—FARABEUF'S RETRACTOR.

These are excellent substitutes for the broad copper spatulæ and retractors of less recent times, which bent when exposed to much strain, and slipped unless that strain was kept up.

Needles.—The best suture needle is a perfectly straight one, of a length adapted to the case in hand, and "triangular-pointed" (Fig. 8, A). Straight, "lancet-pointed" needles are much used, but they are not so serviceable as those first named.

For special operations special needles are required, such as in suturing intestine and in operations for cleft palate and certain fistulæ, but for all ordinary suture purposes the best instrument is the straight needle.

Many surgical needles need only to be mentioned to be strongly condemned. These are the large-curved needles and the half-curved needles which are found in most pocket cases, and which are currently supposed to be used for sewing up wounds of the scalp (Fig. 8, B). If any operator acquires perfect control over these unreasonably-shaped needles they may possibly be of service. I have observed a half-curved needle to be introduced at one spot and its point to emerge at another at some distance from the intended aperture. The surprised operator has withdrawn

it, and on making another attempt, the needle point has again emerged at a remote and unexpected locality.

Hagedorn's needles are excellent. They are flat, easily penetrate the skin, and make a small and clean wound. This wound takes the form of a narrow slit at right angles

Fig. 8.—(A) STRAIGHT TRIANGULAR-POINTED SUTURE NEEDLE; (B) HALF-CURVED SUTURE NEEDLE.

to the line of the incision to be closed by suture, and the thread, if drawn quite tight, cannot greatly enlarge the needle puncture. It must be confessed that the comparative value of this needle has been exaggerated by its inventor, and that the evils it is supposed to avoid are not either so real or so serious as they have been painted.

Hagedorn's diagram representing the terrible gaping and rending of the needle puncture when the line of the puncture is parallel to the line of the operation wound, depicts a condition that I have never met with in real life. This needle is of service in conditions where a straight needle is less easily introduced. It forms an excellent intestinal needle: it is useful in suturing parts which are placed at some depth in a cavity, it is useful in hysterectomy, in operations upon the perineum, upon the tongue, the palate, and the scalp, etc.

The best forms are those with the half-circle or the three-eighth-circle curve. It does not appear that any advantages can be claimed for Hagedorn's half-curved needle or straight needle. If a curved needle has to be used in a needle-holder, then Hagedorn's instruments may be employed.

The needle holder is a little complex, and needs practice before it can be deftly handled. It is difficult to keep clean, and the suture thread is very apt to be caught between the parts of the apparatus.

A very excellent needle-holder for small curved needles of

the ordinary pattern is the simple instrument depicted in Fig. 9.

Hare-lip pins, or suture pins, should be made of hard steel, and should be as rigid as a needle of corresponding size. It is

Fig. 9.—SIMPLE NEEDLE-HOLDER.

not uncommon to find that the pin is of so soft a metal that it can be readily bent double without snapping.

Suture Material.—The best suture material, so far as my experience goes, for operation wounds of almost any kind, is *silkworm gut.* It is in the first place strong, it is as smooth as glass and as solid. As it is not composed of fibres, the fluids of the wound cannot soak into its substance, and therefore if it be retained for longer than the usual time it does not act as a seton. I have frequently, under special circumstances, allowed silkworm-gut sutures to remain in position for fourteen days, and in cases of cleft palate for three weeks, and none of the ordinary evils have attended the practice.

In the case of many wounds which require support for some time after the operation, as in the wound left after the removal of a mammary tumour, together with much skin, it is better, if possible, that the original sutures should be retained than that they should be removed and their place taken by strapping.

Silk sutures must be removed early. It is not to be inferred that the use of silkworm gut should encourage the practice of retaining sutures unduly. A suture should be removed as soon as it can be, but with silkworm gut it is possible to retain the support of the suture in those occasional cases in which such retention is of advantage.

In the next place silkworm gut, although stiff, moulds itself to the position it is made to assume in the wound. Its perfect smoothness renders it easy to introduce, and this

quality, combined with its pliability, renders it easy to remove.

Silkworm-gut sutures should be allowed to soak for some ten minutes before use in carbolised water. Such immersion renders them less slippery and less stiff.

The suture should not be tied in a knot. If a knot be attempted, and be pulled tight, the thread is almost certain to snap. Like metal wire, this material can bear a great strain in a straight line, but it is apt to give if dragged upon when sharply bent upon itself.

The suture is secured by making use of the first stage of what Fergusson calls the surgeon's knot, "which is made by passing one end of the thread twice over the other (Fig. 10), before turning each back again to form the second noose."

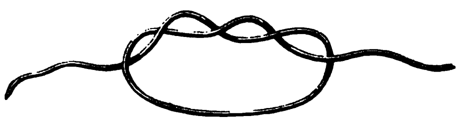

Fig. 10.—FIRST STAGE OF THE SURGEON'S KNOT.

With silkworm gut this second noose should not be formed. The thread should be twisted as shown in Fig. 10, and then pulled tight. If properly applied it will not give. In this matter of securing the suture, silkworm gut presents a great advantage over other materials. There is no knot to press upon the tissues; the interwoven suture threads lie absolutely flat, and the edges of the wound are approximated with the greatest precision. For plastic operations and for such a procedure as the closure of a ruptured perineum, this suture material is invaluable. The threads should be left long, and it will be found to be possible to loosen or tighten the suture after it has been "tied," as it lies *in situ*.

In cases where the fineness of the resulting scar is a matter of importance, as in operations upon the face or neck, this material should always be employed.

Threads of two or three different sizes can be obtained, and the red-stained variety is the more convenient as being the more easily seen.

In the few instances in which silkworm gut, by reason of its stiffness, cannot be employed, a silk suture thread may be used. The form of silk most commonly employed is that known as Chinese twist. This material has a disposition to

kink and to curl up even after it has been soaked in water for some time.

"Turner's patent plaited suture silk" does not possess these disadvantages. It is very readily applied, presents a smoother surface than the Chinese twist, and is apparently the best form of the silk suture material.

Ligature Material.—Catgut still remains the material best suited for ligatures, especially as of late considerable improvements have taken place in its manufacture.

The most convenient, and apparently the best variety, is that known as sulpho-chromic gut, which is dry, and sold in definite and well-proportioned sizes. See also the remarks upon the ligature in the preliminary section on the Ligature of Arteries.

ACCESSORIES.

Instrument trays are essential. Those used in hospitals are usually made of white china. A more convenient form for private practice is the papier-mâché tray, which is light, not easily broken, inexpensive, and can be obtained in many sizes.

The instruments should be arranged neatly in one or more trays, and should be classified, *i.e.*, the cutting instruments in one part, the forceps in another, the scissors in a third.

As the papier-mâché tray is dark, needles, which are not easily seen and are easily lost, may be placed in a small saucer by themselves. If a great number of pressure or clamp forceps have to be at hand, they may be conveniently placed in a small basin with steep sides. This enables them to be well displayed, and prevents them from becoming entangled.

The trays, basins, etc., are filled with a one in thirty solution of pure carbolic acid, and in this solution the instruments remain immersed.

An *irrigator* and proper *receivers* are necessary in all but the smallest operations.

A wound surface should be cleaned by the action of a steady stream of carbolised water, and not by the rough rubbing movements of a vigorously applied sponge.

A large conical glass irrigator, with a tube of good lumen, and a suitable tap, is the best apparatus.

A syringe is in most cases to be condemned. It is awkward

to use, is apt to get out of order, involves much waste of time, and sends upon the wound surface an ill-regulated, spasmodic, and usually too violent stream of water.

The most convenient receivers are made of papier-mâché or hard gutta-percha, and the most useful form is that known as the "kidney shape."

The receiver is held beneath the wound surface, and receives the fluid from the irrigator or the wrung-out sponge.

Sponges.—Ordinary sponges of suitable size answer well enough for the majority of cases. In abdominal operations the finest Turkey sponge should be used, and the same provision may be made for plastic procedures, and for all such operations as require a very clear view of the depths of the wound. Thus in securing the lingual artery, a well-shaped Turkey sponge makes no little difference in the circumstances of the operation when the vicinity of the vessel is approached.

New sponges must be carefully cleaned and freed from every particle of sand. This is effected by having them well beaten and shaken in calico bags, and by then immersing them for some twenty-four hours in warm water, in which also they should be frequently rinsed out.

Mr. Doran advises that the sponges should then be immersed for twelve hours in a one in five solution of sulphurous acid. This serves to free them from all organic impurities.

The method recommended by Mr. Greig Smith for cleansing sponges after use at an operation is very efficacious.

The sponges should under no circumstances be boiled, or even placed in boiling water. They should be first well washed and rinsed in warm water, and then placed in a solution of ordinary washing soda (about a pound of soda being employed to every dozen sponges). This solution dissolves out the blood and fibrine, and in it they are repeatedly washed and squeezed. When every particle of filth has been removed they are once more well cleansed in water, and are then allowed to stand for a few hours in a one in twenty carbolic solution.

They are finally squeezed out and dried, and are kept in a dry place until required for use.

Masses of the finest absorbent wool rolled up so as to be about the size of ordinary sponges, answer well in many operations in the place of sponges.

Not a few surgeons discard sponges altogether.

Sponges, together with all surgical dressings, are most conveniently stored in close-fitting tin boxes.

The Steam Spray.—It has been conclusively shown that the antiseptic spray is not essential to the success of an operation. By the great majority of surgeons its use has been entirely abandoned.

It is still retained by some for such operations as involve the opening of the abdomen or the pleural cavity.

Certain surgeons still hold that no abdominal section should be performed except under the "protection" of the spray: others have made it clear that abdominal operations of every degree can be carried out with safety and success quite independently of this apparatus.

The question of the use of the spray in this class of operation is well discussed by Mr. Greig Smith in the following passages:—"Spray or no spray is probably a choice of evils, and of not very great evils. On the one side the evil is irritation of the peritoneum from the germicide, cooling of the peritoneal surfaces from wetting and evaporation, and poisoning from absorption of the antiseptic agent used. On the other side the evil is a danger to be avoided—namely, septic peritonitis, from contamination with the surrounding air. Now, there is no doubt whatever that the greatest risks of peritonitis arise from impurities of hands, sponges, and instruments, and not from air. The spray has little influence over these; but repeated cleansing with soap and water will render them practically pure. An antiseptician who scrupulously attends to cleansing of hands and instruments is in a better position than one who places all his trust in the spray." It must be allowed that the spray is inconvenient to the surgeon, and that the moisture-laden atmosphere produced by it is not the best for the patient to breathe. The chief point to be claimed for the spray, and almost the only point, is that it tends to purify the atmosphere around the operating table. When an operation is performed in a healthy, open, country place, there can be no excuse for

the use of this somewhat cumbrous apparatus. If the air be acknowledged to be pure, the steam of the spray is a needless addition to the atmosphere. On the other hand, the use of this antiseptic measure would appear to be permissible during the performance of an abdominal section, in the general hospital of a crowded city. The theatre in such an institution may be close, and full of spectators fresh from the dissecting and post-mortem rooms; the atmosphere could not be considered pure, and if a carbolised spray can improve its condition it should certainly be employed.

CHAPTER V.

The Elements of Operative Surgery.

The Arrangements of the Operating Table.—The surgeon, before he takes the knife in his hand, should have very clearly made up his mind, not only what he intends to do, but also how he intends to do it. In like manner, he should precisely instruct his assistants as to their duties and the manner of performing them. Each man should have his place and his especial office, and to this he should devote his whole attention.

The patient should be placed in the most convenient position. The part to be operated upon should be well exposed. The rest of the body should be neatly and carefully covered up, and should be surrounded by precisely folded macintoshes. Not one particle of blanket or of flannel should be visible. The "fluff" of these materials readily comes off on the wet hand, and is easily picked up by the instruments, and the transference of many particles of hair into the wound is distinctly to be avoided. Macintosh sheets should form the only material with which it is possible for the fingers or the instruments to come in contact.

In the most convenient place below the site of the operation two or more large coarse sponges should be wedged, so as to absorb any blood which may gravitate from the wound. They should be changed as often as required. In the case of an excision of the breast, for example, the sponges may be wedged under the posterior margin of the axilla, and between the thorax and the macintosh covering the table. In the case of an operation for hernia or a castration they should be placed against the perineum. By adopting this plan, blood cannot trickle beneath the patient's back or limbs, and much time is saved, on the completion of the operation, which would otherwise be taken up in cleaning the dependent parts of the body.

Every detail should be arranged as tidily, as clearly, and as methodically as possible.

Each instrument should have its proper place in the instrument tray. The operator should not rinse his hands in the solution contained in the tray, nor dip sponges in it. If common care be not exercised, it is possible for the solution to become so opaque that the instruments cannot be readily identified. I have observed an instance where a tumour which had been removed was placed, in a fit of absence of mind and in the hurry of the operation, in the instrument tray, with the result that the pressure and artery forceps, which were at once required, were rendered invisible.

A basin containing warm carbolised water should be placed on the instrument table, so that the surgeon can cleanse his hands rapidly from time to time.

The wiping of blood-stained hands upon a dry towel is neither an easy nor a satisfactory method of cleaning them.

The assistant should take every care that all blood issuing from the wound is sponged up at once. If this be not done, blood may cover everything, and may be carried about by one and another over the whole field of the operation. Small instruments, moreover, may be lost among the clots which accumulate below the wound, and the necessary manipulations of the operator are carried on in an atmosphere of sticky uncleanness. An active assistant may make any ordinary operation appear almost bloodless, and his efforts will not end with appearances merely, but will conduce to that precise cleanliness which is so essential about an operating table, and to that "clear field" which is so much prized by the neat operator.

As each instrument is used, it should be returned at once to its proper place in the tray. There is a disposition to leave the instruments lying about on the operating table, on the macintosh, and on convenient parts of the patient's body. This slovenly habit renders it possible for the operation to be stopped while the surgeon and his assistants are hunting for lost forceps among the folds of the patient's clothing or beneath his limbs.

The Making of the Wound.—The question of the precise manner in which the scalpel or knife should be held in

making an incision must be left to a great extent to the taste and custom of the individual operator. In making the lightest and finest incisions, as in exposing an artery and in some plastic operations, it is well that the scalpel should be held between the thumb and the fingers like a pen, the thickest part of the handle being the part grasped (Fig. 11).

Fig. 11.

If more power be required, the scalpel may be held somewhat as a violin bow is held, in the position shown in Fig. 12. "This method," as Fergusson observes, "requires great steadiness naturally, but with practice, much ease, elegance, and dexterity may be displayed when the knife is thus held, and even the most minute dissections may be effected with the hand and scalpel in the attitude here represented."

In the making of cuts requiring still more power, as in the making of ordinary skin incisions, and in the handling of instruments larger than the scalpel, the knife may be held in the manner of a dinner knife, with the forefinger upon the back of the blade (Fig. 13).

Fig. 12.

In operating, the fact should never be lost sight of that the best wound to heal is a clean incised one, and that a lacerated or contused wound is a blemish on the work of the operator.

It is important also to bear in mind that the usual operation wound is not limited to the skin; it extends into the depths of the part operated upon. The wound should be an incised one, whenever possible, throughout its whole extent. The skin may have been divided by a clean cut, while the deeper tissues may have been severed by

Fig. 13.

needless tearing and laceration. Defects in healing are more often met with in the depths of a wound than in the integumentary part of it.

Each cut should be made cleanly and precisely, and with as much care and deliberateness as an engraver would bestow upon each movement of his tool. In a skin incision the wound should be as complete at its two extremities as at its centre. It should be of even depth throughout, be well finished, and present no "tails."

The depths of the wound should not be *torn open* with the fingers. The fingers are useful enough and necessary enough in opening up the depths of some operation wounds, especially when ligaturing arteries. The fingers answer perfectly for separating some muscles, as in exposing the anterior tibial artery; but, while inter-muscular spaces are conveniently opened up with the fingers, muscle tissue should never be torn through by them. Many tumours are enucleated almost by the fingers alone; but, in general terms, it may be said that the more that is done with the scalpel and forceps the better.

There is a great disposition towards the needless and reckless use of the "handle of the scalpel." Those who would employ this means in such an operation as the exposure of an artery would incise the skin in the usual way, and would then attempt the rest of the operation (so far as the reaching of the vessel is concerned) with the forceps, the fingers, and the handle of the scalpel. A moderate use of both finger and handle of scalpel is well enough, especially when a search for a deep artery is being made, but the moderation must be within the narrowest limits.

A perfectly needless degree of injury may be inflicted upon the tissues by this uncouth method of operating; parts are lacerated and displaced, and the anatomical details of the region are rendered obscure. It is a method which finds favour alone with those who use a scalpel with fear and with unsteady hands, or who have but a confused idea of the topography of the district which they are so roughly invading.

The tearing of the tissues between *two pairs of dissecting forceps* is still more reprehensible. It is, perhaps, not uncommon in operating upon hernia to make an incision to

a certain depth, and then attempt to remove the coverings of the sac by picking up layer after layer and tearing them through between two pairs of forceps. The operator who exposes a sac by this method, and who occasionally aids the "dissection" by the vigorous use of his forefinger, may rest assured that there is no worse way of operating, nor one more uncertain, nor—within reasonable limits—more dangerous.

There remains, however, one method of extending an operation wound which yields to none in intrinsic badness. It is the method represented by the use of the *director*. This sturdy and dangerous piece of steel may be employed in two ways. The first plan may be illustrated by the operation of ligaturing the common carotid artery. The skin and the subcutaneous tissues, with the platysma, are divided, and the anterior edge of the sterno-mastoid is possibly exposed. The surgeon now thrusts a forefinger into the wound and enlarges it—with the utmost roughness—by tearing. He now puts aside the scalpel, and proceeds to expose the artery with the dissecting forceps in one hand and the sharp-pointed steel director in the other. This method may be called dissecting by tearing. The director when so employed is infinitely more dangerous than the handle of the scalpel. Tracts of connective tissue are opened up by its point; veins may be penetrated or torn; nerves and other delicate structures are heedlessly bruised.

Great force has to be employed, and a wound of the least desirable character is produced. In ligaturing such an artery as the external iliac, the director becomes peculiarly dangerous, and recorded cases show that in that operation it has not infrequently been forced through the peritoneum.

This barbarous procedure compares forcibly with the right method of operating, in which the whole wound represents a clean incised cut from its surface to its deepest part. Each layer of tissue has been neatly divided, every step of the operation has been certain and precise, every anatomical feature has been recognised, and the sheath of the artery has received the least possible amount of hurt.

The second method of using the director may be illustrated by the operation for hernia or by lumbar colotomy.

The skin incision is made, and the director is at once taken in hand. A hole is made in the tissues, and into this the crude piece of steel is thrust. The tissues which cover in the director are then hacked through with the scalpel. Another hole is made, or the director is thrust boldly into the depths of the incision, and another layer of tissue is left mangled. In this way the sac of a hernia is exposed, and a tract of needlessly bruised and lacerated tissue is left behind.

The director may be thrust into the distended and softened bowel, or the bowel may overlap the margin of the director, and so be sliced open by the knife. The essential feature of the method is that the steps of the operation are undertaken by the director, and that the scalpel plays a subsidiary part.

In performing colotomy with a director, the separate layers of fascia and of muscle are taken up by this precious instrument, and divided upon it. As often as not, the director breaks through the layer of muscle which it is exposing, and so the operator is spared the use of the knife. The resulting wound is a deep hole bounded by mangled tissues.

The art of operative surgery would benefit greatly if the director were to be entirely banished from the list of surgical instruments. A director is certainly of service in operating upon fistula, in dealing with sinuses, in disposing of some false membranes about the viscera, and in herniotomy. In the latter operation, however, it is used only when the stricture is being divided, and serves to save the bowel from the undue pressure of the finger. A surgeon who cannot cut down upon an artery, or expose a hernial sac or a subcutaneous cyst, or who cannot reach the transversalis fascia in the loin without the use of a director, had better abandon operating. The liberal employment of a director is a demonstration of inefficiency, and the long list of special directors is not creditable to surgical progress.

In exposing a deep part, such as the sac of the hernia, the whole process should be effected by clean incisions. The knife should follow the same precise line, and be carried neatly from one end of the wound to the other.

The layer of tissue next to be divided should be carefully

picked up with the forceps, and the piece so held may be gently moved from side to side, in order that its density, its thickness, and its freedom from deeper connections may be made out. Now and then, in approaching a hernial sac, the tissues may be pinched up between the finger and the thumb, so that the thickness of the remaining layers may be estimated, and the position of the contained bowel or omentum defined.

It is desirable also that the margin of the wound should not be bruised or damaged by uncouth retractors. The simple

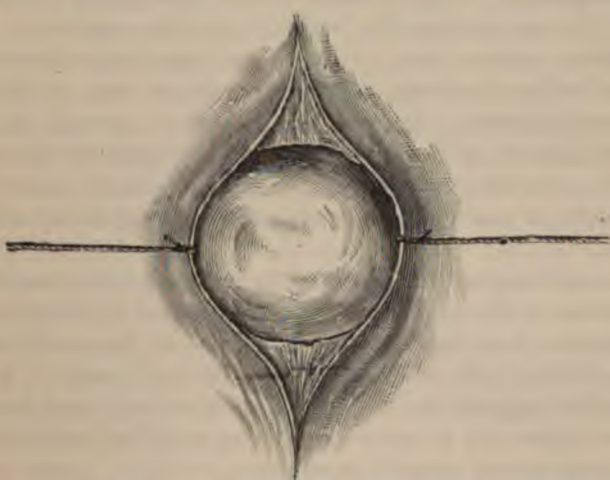

Fig. 14.—MODE OF EXPOSING A TUMOUR BY LIGATURE OR THREAD RETRACTORS.

wound-hooks, and the wound-retractors described already (page 40) effect the least disturbance of the divided tissues and the least encroachment upon the field of the operation. Retractors of all kinds, however, must be used with a light hand.

In performing many small operations I make use of what may be termed *ligature retractors*. After the incision through the skin and the subcutaneous tissues and fasciæ has been made, the margins of the wound are held aside by means of silk ligatures, which are inserted close to the cut edge on each side (Fig. 14).

These ligatures occupy no room, interfere in no way with the surgeon's movements, and do not encroach upon the field of operation. They should be of considerable length, so that the assistant who holds them may be well out of the way. When they are employed upon a limb, one of the threads may be passed under the limb, so that one assistant can hold both threads upon the same side of the extremity.

These retractors are very useful in any operation for the removal of superficial tumours, *e.g.*, in dissecting out a diseased bursa patellæ. The edges of the wound can be kept separated to the utmost extent throughout the operation. In performing the radical cure for varicocele, also, no better means can be found of retracting the scrotal tissues, while the veins are being exposed, than is afforded by these threads. In such an operation as that required for the ligature of the lingual artery, the edges of the wound can be admirably separated by silk retractors, which have the merit of never slipping, and of occupying no appreciable space.

In performing some operations which involve wounds of considerable depth, I have sometimes found it convenient to attach a long ligature thread to a deep fascia which has been divided, but which needs to be held aside. A long thread so applied in the depths of a wound (and it needs to be applied by a curved needle in a holder) often proves the most efficient possible retractor.

It is desirable also in *all* cases that the incision should be long enough for the purposes of the operation. The attempt to evacuate a tumour through the smallest possible incision often involves a considerable bruising and laceration of the edges of the wound in the attempt to drag or squeeze the mass through the narrow opening.

A long, cleanly incised wound is always to be preferred to a shorter wound with contused margins.

Surgeons who boast of the smallness of their incisions are proud of what is at most but a questionable feat. While it is most essential that a wound should never be larger than is necessary, at the same time it is important that the operator should have a good view of the parts with which he is dealing. There can be no possible object in attempting

to ligature the common carotid through an incision an inch long. It can be done as a feat; as a surgical procedure it involves much cutting in the dark, and adds a quite unnecessary danger to the operation.

In performing operations upon the abdomen especially is it desirable that the parts to be dealt with should be well exposed; and to attempt to gauge the manipulative skill of an operator by the smallness of his laparotomy wound is often to attempt a criticism upon false premisses.

The Arrest of Bleeding.—The sponging of the wound requires a little care. The sponge should be as well wrung out as possible, and should be applied to the surface with a quick, firm, decisive touch. There should be no patting of the wound, nor should the sponge be roughly rubbed over it, or swept heavily across it. Rough sponging cannot do other than injury to the raw tissues, besides being inefficient and involving waste of time.

The bleeding surface should be well exposed, and bleeding points should be seized with the pressure forceps as soon as they are detected. It is needless to say that the larger vessels should be secured first. Pressure forceps are of necessity used in haste as a rule, but every care should be taken to grasp the vessel neatly and completely, and to include no more tissue than is absolutely necessary between the blades of the forceps.

To grasp a large mass of tissue about a bleeding point, and to allow the forceps to compress it with the full force of the spring during any considerable period of time, is obviously bad. The structures so dealt with are needlessly crushed; and it may be no matter of surprise if they sometimes slough. If in the hurry incidental to copious hæmorrhage the tissues are somewhat recklessly seized, the forceps should be readjusted with more care when the urgency is over.

Simple oozing will usually yield to mere exposure to the air, to the effect of a few seconds of time, to the pressure of a nearly dry sponge, or to the action of ice or of hot water.

Small vessels need only the treatment involved by the continued pressure of the forceps. The longer they can

be left on, the better, and if then carefully removed, the artery will usually be found to have ceased to bleed.

Thus, in excision of the breast it is seldom found necessary to ligature any vessels. Continued pressure suffices to close all such as are not of fair size. It will be found in performing an amputation that by the time the large arteries have been secured and the flaps cleaned up, the pressure which has all the time been kept up on the lesser vessels has sufficed to occlude them.

Vessels a little larger than those alluded to may usually be dealt with by torsion. No especial torsion forceps are required. If the artery has been neatly and cleanly picked up by the point of the pressure forceps, it can be occluded by torsion without removing the forceps. The vessel should be drawn well out, and the instrument then twisted round three or four times between the fingers and thumb, until there is a sense of lack of resistance.

In dealing with the larger arteries, and with main vessels, a catgut ligature must be used. The vessel, while yet the pressure forceps occlude it, should be gently isolated, and should then be grasped by a pair of artery forceps (as the first instrument is removed) and securely ligatured.

In the case of free bleeding from one or more points upon a surface, continued pressure—to be maintained in the subsequent dressing of the case—is the simplest measure.

In instances in which such pressure cannot be applied, the bleeding point may be picked up with a tenaculum, and then secured by silkworm gut. This thread is the material that of all others is most likely to retain a hold of the tissues under these conditions. The gut should be applied in the manner described in speaking of sutures (page 44): it should not be tied in a knot.

It should be an element in the dressing of operation cases that substantial pressure is kept up in order to control any continued disposition to bleed.

The Closure of the Wound.—In previous sections the question of the selection of a suture material and of suture needles is dealt with, and the manner in which sutures of silkworm gut are to be secured is described (page 43). This

material may be used in closing all operation wounds, with very few exceptions.

Before introducing the sutures, the wound should be most carefully cleaned, and its edges accurately approximated. It is most desirable that the margins of the wound should be well defined, and that in uniting it parts which were in contact before the operation should be once more brought into apposition. As the tissues left after the removal of a tumour or the reduction of a large hernia are lax, and the integument is flabby and in folds, it is easy for the wound to be irregularly united and to be puckered in one place, and too tightly drawn in another.

In all but the smallest incisions, therefore, the edges of the wound should be put upon the stretch, and be so adjusted to one another that they form when in contact a simple line. This is effected by introducing a large blunt hook into each angle of the wound in the manner shown (Fig. 15), and by

Fig. 15.—METHOD OF STEADYING THE MARGINS OF A WOUND WITH BLUNT HOOKS DURING THE INTRODUCTION OF THE SUTURES.

then drawing upon the hooks until the wound margins are parallel and are approximated to one another. The hooks should be of good size, and I have found that the most convenient curve is that of half of a circle with a diameter of three-quarters of an inch.

The needle should be introduced as close to the free edge of the wound as is consistent with a good hold upon the tissues. If the suture be applied too near, the hold obtained is slender and the thread is apt to cut through. If it be inserted at too great a distance from the wound, the margins of the incision are liable to become turned in upon one another.

In closing large wounds, and in inserting sutures which

will be exposed to strain (as in wounds of the abdomen, deep wounds of fleshy parts, and amputation flaps), it is well to place the main sutures at some distance apart (about three-fourths of an inch), and some way (about three-eighths of an inch) from the edge of the wound. A very good hold is thus obtained upon the tissues. Between these main sutures smaller secondary sutures are inserted, which are introduced close to the margin of the wound.

In subsequent paragraphs special details are given as to the method of closing particular incisions (*vide* Abdominal Section, etc.).

Sutures are probably more often drawn too tightly than tied too lightly.

In using silk the knot should be so placed as not to press upon the skin at the needle aperture.

The sutures described unite merely the skin-cut, and it must be remembered that in an operation incision this skin-wound forms the least part of the lesion. The *main wound*, represented by two large raw surfaces, lies beneath the integument. Although the sutures may close the cut in the skin efficiently, they may leave the depths of the wound unaffected, and while the minor surface incision is perfectly adjusted, the great wound, which spreads deep into the tissues, remains gaping. The union of the skin, indeed, may convert the latter into a cavity with raw and flaccid walls, which are at no place in contact with one another. Here, then, is an actual evil —the production of a large subcutaneous cavity in which accumulations can readily occur and decomposition take place.

In placing the parts in the best position for healing, the union of the severed tissues beneath the surface and *the obliteration of the wound cavity* become matters of the first importance. It is with the greater lesion the surgeon should concern himself, rather than with the mere cut in the skin. A little experience will soon enforce the fact that the mere hiding of the depths of the wound by sewing up the rent in the integument does not constitute a closure of the breach. The cutaneous wound after it has been closed will, as a rule, heal kindly enough.

If, on the other hand, there be any defect in the healing,

it usually proceeds from the depths of the incision. When a wound "breaks down," the breaking down most commonly starts in the deep wound, and not in that in the integument. The chief local troubles attending large incisions concern the subcutaneous part of the lesion, and take such forms as the accumulation of blood, the bagging of pus, the formation of sinuses, the spreading of inflammation into the adjacent cellular tissue, and the like.

To ensure the best possible adjustment of the whole surface of the wound and the obliteration of what is conveniently termed the wound cavity, the following method should be adopted. It may be illustrated by a case of excision of the breast:—All hæmorrhage has been checked, and the whole surface of the wide-open wound has been freed from blood-clot and from fragments of tissue, and has been well cleansed by a stream of carbolised lotion which has been allowed to run over it from an irrigator. The wound-surface has not been scrubbed clean with a sponge, as is a common practice. A sponge so applied inflicts a quite needless damage upon the already injured tissues, and may cause an occluded blood-vessel to start bleeding again.

The margins of the wound are now approximated, and rendered parallel and tense by means of the two blunt hooks, and the sutures are introduced, one by one, commencing at the highest part of the wound. The sutures are not tied at first, but are merely introduced through the tissues. They may be so inserted throughout the whole length of the wound, or, as is more convenient, through the upper or least dependent part of it only at first. Before these sutures are secured and the first part of the incision closed, the corresponding deep part of the wound should be again cleaned out with the irrigator or dried with the sponge; and as the surgeon ties each suture an assistant gently wipes the edges of the wound for the last time, and then with a large sponge compresses firmly all such part of the cut as has been closed up. This pressure should never be relaxed. In the case of an excision of the breast, it at once compresses the integuments against the thorax, brings the deep surfaces of the wound well together, and quite obliterates the cavity of the wound. Any further tendency to oozing is checked, and

there is no space possible in which an exudation should collect.

The pressure closes the breach, and the assistant must take care that it is never for a moment relaxed.

Following the same method, the surgeon closes in the rest of the wound, dealing with the most dependent part last. Before he ties a suture he satisfies himself that the corresponding depths of the wound are clean and practically dry. As he closes the skin wound, inch by inch, the assistant with the pressure-bearing sponge follows his hands; the wound cavity is thus gradually and certainly obliterated, and will remain so as long as the compression is maintained. A drainage tube is very often not needed, because there is little or no space to drain, and if a small gap is left between the sutures at the most dependent part of the wound a safety valve is provided in case of any accident. Without relaxing the pressure kept up upon the wound, the sponges are cautiously and gradually replaced by the dressing to be employed. This will probably consist of a sponge or sponges well dusted with iodoform and a very large quantity of absorbent wool. The patient's arm is now carried right across the wound, the hand of the injured side resting upon the opposite shoulder, and in this position the limb is very firmly secured in the manner to be afterwards described, and is made to act the part of a compressing splint. The wound cavity is practically obliterated by pressure, and that pressure should be maintained until the wound has healed.

This method can be applied to almost any deep wound, and even to incisions involving the neck. The principle remains unchanged although the *modus operandi* may vary.

In the case of amputations, a like pressure, very cautiously and discreetly applied, serves to keep the raw surfaces of flaps in perfect apposition, to obliterate any space which may exist between them, to prevent any after oozing of blood, and to allow no cavity to exist in which an accumulation could take place. Under this method wounds heal admirably, and I venture to think that it reduces the complications of wounds to the smallest limits.

The surgeon must exercise some ingenuity in devising the best method of applying pressure in each particular case; he

must make use of it with discretion, and must recognise the possibility of its being unsuited in some local conditions.

Some operators have advised the use of *deep or buried sutures*, and have claimed that the deeply-placed wound surfaces are thereby as effectually brought together as are the margins of the skin incision. They advise, moreover—especially in the adjusting of amputation flaps—that severed parts should be united by suture like to like—*i.e.*, muscle to muscle, fascia to fascia, aponeurosis to aponeurosis.

In the case of a deep wound in which important structures have been divided, such as tendons and dense fasciæ, it may be desirable—in obedience to a rudimentary principle in surgery—to specially unite the severed tissues with sutures. Such a proceeding would, however, be of quite limited application, and the needs for it may be considered to be accidental. It has not been shown by those who unite flaps by a number of so-called buried sutures that the method possesses any definite advantage in actual practice.

The objections to be urged against deep sutures generally are the following:—

Their application involves time and prolongs the operation. The tissues are needlessly disturbed, and possibly damaged, in the application of the sutures. The threads employed are at best foreign substances, and the introduction of ten or twenty unnecessary fragments of catgut into the depths of a wound is at least undesirable. Moreover, the buried sutures do not offer the best means, either of approximating the raw surfaces of a deep wound, or of obliterating the wound cavity, and in many notable examples—such as is afforded by an excision of the breast—the application is scarcely possible.

The length of time during which surface sutures may be *retained* cannot be arbitrarily stated. Those of silk soon cause irritation, and if not removed within a certain time are apt to produce sutural abscesses. From five to eight days will approximately represent the limit of time during which such sutures may with safety be retained.

With silkworm gut, if properly applied, the case is different. It is exceedingly uncommon for these sutures to produce sutural abscesses, and the irritation which they

excite is, in the majority of cases, quite insignificant. I have often allowed silkworm-gut sutures to remain in the wound for ten or fourteen days, and in the operation for the closure of a cleft palate they may be left in for three weeks if necessary. If the ends be left long enough, the suture can be tightened or loosened while it remains *in situ;* they are readily removed, and leave very little evidence of their presence.

The almost exclusive use of this material for the last few years in operation cases of all kinds has led me to believe that it forms the very best substance for closing wounds with which we are acquainted.

The Draining of the Wound.—In many cases of operation wounds no drainage tube of any kind is required. The great essential in dealing with a wound is, as already said, to bring all parts of the cut surfaces together, and to obliterate the wound cavity. If this be efficiently done, there is no place in which exudations can accumulate, and no area to drain.

If, on the other hand, the margins of the skin wound are very closely united while the depths of the incision are left unheeded, then it will often happen that a closed subcutaneous cavity is left, into which the discharges from the divided tissues may flow, and from which they have no way to escape.

If a cavity be quite unavoidable, then a drainage tube must be inserted; but if no cavity exist, then the tube serves merely to separate the cut surfaces and to impede their proper union. The actual forcing asunder of the surfaces of some simple deep wounds, such as may be left after the ligature of an artery, appears to be quite unwarrantable, and to be opposed to the simplest principles of surgery.

The drainage tube has fallen into discredit mainly on account of its indiscriminate and unreasonable employment as a routine feature in almost every operation case.

From large wound surfaces, such as are left after an amputation or the removal of a tumour, a not inconsiderable oozing of blood and serum may be expected. The escape of this is encouraged by the pressure which is maintained upon the parts, by not introducing the sutures too closely, and by

leaving some gap between them at the most dependent part of the wound.

Should these means appear inefficient, then a tube may be inserted and removed in 24 or 48 hours.

In many cases where pressure cannot be well applied—as in some parts of the neck—and where gravity does not aid the escape of exudations, and where also a neatly adjusted skin wound is a matter of importance, a drain may be introduced. But in such cases there very rarely remains any excuse for retaining it for more than 24, or, at the most, 30 hours, after the operation.

These are instances where a tube may be serviceable, and the other conditions under which it may be employed with advantage are such as the following:—

(*a*) When a cavity is produced at the bottom of which tissue is exposed which could not be expected to join in a normal healing process. This is a condition met with after some resections of bone, after some operations upon diseased joints, and after the partial removal of cystic growths.

(*b*) When there is, or is likely to be, a considerable oozing of blood, as in incomplete ovariotomies.

(*c*) When sinuses or inflamed districts are opened up in the course of the operation, and when the involved tissues are allowed to remain in whole or in part. This is illustrated by an amputation for disease, where an old sinus occupies the substance of a flap, or the track of a sinus is exposed in the depth of the stump. Although these sinuses may have been well scraped, they can scarcely be expected to take a wholesome part in the healing process.

(*d*) When much-damaged tissues are left in the depths of a wound, as in cases where deeply-attached tumours have been removed with great difficulty, and with much bruising and laceration of the soft parts, and the application possibly of many ligatures. In such cases the insertion of a drainage tube is a wise precaution.

(*e*) When an operation has been performed upon an œdematous or infiltrated part, it is inevitable that much oozing will occur during at least the first few days, and this should be allowed to escape freely. In a case therefore of amputation, where the flaps are formed out of tissues which

are still œdematous, a tube may be employed to give free vent to the fluid which will ooze from the cut surfaces.

(*f*) Drainage may be employed in certain cases when the wound is foul at the time of the operation, in some operations near the anus, and in instances where a fistula is inevitable, as after certain operations upon the bowel, kidney, etc.

The Local Conditions which influence Primary Healing. —The circumstances which affect the future well-being of an operation wound are very numerous. The more general of these have been already considered, and are such as concern the health of the patient, his surroundings, and the magnitude and duration of the operation.

The local conditions which encourage sound healing by first intention have been also in some way alluded to. They may be briefly summarised as follows:—

1. The wound is a clean cut, and the surfaces of the wound have been neither lacerated nor contused.

2. The tissues dealt with are healthy, are free from any infiltration, are left well supplied with blood, and are removed from any source of septic infection.

3. The wound surfaces have not been roughly sponged, and have not been washed with too strong or too irritating an antiseptic solution.

4. There is no tension upon the sutures, and they have not been applied too closely.

5. All hæmorrhage from the divided tissues has been checked.

6. The edges of the wound have been brought well together, and the wound cavity has been obliterated by pressure.

CHAPTER VI.

The After-Treatment of the Wound.

Immense progress has been made of late years in the treatment of wounds. In this progress the most prominent figure is that of Sir Joseph Lister. To him belongs the honour of having effected a reformation in surgery, of having established upon a new and scientific basis the ancient art of healing, of having freed the operator from the more grievous of the dangers which surround him, and of having greatly extended the powers and possibilities of the surgeon's art.

As to the exact method of dressing a wound, and the materials to be used in that dressing, it is impossible to be dogmatic, or even to be precise.

Probably at no time have the modes of dealing with wounds been more numerous, nor has the application of a few common principles been more diverse.

All surgeons endeavour that the wound shall be quite clean; shall be aseptic; shall not be irritated; shall be kept at rest. One surgeon accomplishes these ends in one way and another in another, and the results are equal. He who considers that his method of dealing with a wound is the most perfect will find that his neighbour, who adopts very different details, obtains an identical measure of success.

New antiseptic agents appear from time to time upon the scene. They are pursued, are vaunted as perfect, are diligently employed, and then not a few of them fade away, some very gradually, others with the suddenness of the South Sea Bubble.

With these reservations, I might describe the method of dealing with operation wounds which has appeared to me to be satisfactory.

The part must be kept absolutely at rest. Mere confinement

in bed, with the support of a proper pillow, may suffice to effect this, or a special splint or retentive apparatus may be employed.

The part is kept raised, so that the circulation of the blood through it may be as much relieved as possible, and is so placed that the drainage of any discharges may be readily effected.

The wound itself is dressed simply with sponges dusted with iodoform. These are held in place by much absorbent wool, over which, possibly, a layer of gauze is placed.

A bandage is then so applied as to bring pressure to bear upon the wound. The effect of this is that the edges of the incision are kept well together, the cavity of the wound is obliterated, any tendency to oozing is prevented, the use of a drainage tube is rendered unnecessary, and the parts concerned in the wound are kept perfectly at rest.

No material keeps up a more effective form of pressure than a sponge. Sponges so employed can, after cleaning, be used over and over again. There should be a liberal covering of wool, as it tends to equalise and diffuse the pressure employed. The ordinary carbolic gauze answers the part of keeping the wool well in place, as it adheres a little to the skin.

The amount of pressure employed must depend upon the circumstances of the individual case. Unlimited pressure would obviously not be employed in cases where the vascular supply of the part is slight and the patient very old.

The simpler wounds, such as those following abdominal section, the ligature of an artery, or the removal of a small growth, need not be disturbed for a week. Such wounds as result from excision of the breast or an uncomplicated amputation may be left for three to five days. If much oozing be anticipated, the wound may be dressed at the end of twenty-four hours, and then left for four or five days.

In the place of the natural sponge the "artificial sponge" answers fairly well.

Tillmann's "dressing linen" is an admirable application for wounds. It is soft and compressible, and very absorbent, and possesses the great good quality of not sticking to the wound.

No stronger antiseptic lotion is used than a one in forty,

or in some cases a one in thirty, solution of pure carbolic acid.

The wounded part should be kept in the open air—*i.e.*, be as far as possible uncovered by the bed-clothes. This will be more or less inevitable with wounds of the head, neck, and upper extremity. The lower limb, after operation, should be quite uncovered by the bed-clothes. The atmosphere under bed-clothes is limited, is hot, is moist, and is frequently foul, as after the use of the bed-pan or the escape of flatus. If there be any truth in the principles which underlie antiseptic surgery, no atmosphere could be worse for a wound. The exposed limb may be wrapped up during the cold weather, and in my wards, where no wound of the extremities is ever allowed to be covered by bed-clothes, I have never heard any complaint on the ground of the part being unduly cold. Fresh wounds, as well as old ulcers, have healed with greater readiness and certainty since I introduced this rule.

In operations about the pelvis, such as castration and the radical cure of varicocele, the part can be kept in a reasonably healthy atmosphere by a simple arrangement of the clothes over a bed cradle. Unless there be some indication to the contrary, the wounds resulting from these operations should be dressed after every action of the bowels.

Part II.

THE ADMINISTRATION OF ANÆSTHETICS.

[*This section has been specially written by* FREDERIC WM. HEWITT, M.A., M.D., CANTAB., *Anæsthetist to and Lecturer on Anæsthetics at the London Hospital.*]

CHAPTER I.

THE ANÆSTHETIC AGENTS MOST COMMONLY EMPLOYED: THEIR PROPERTIES: AND THE EFFECTS WHICH THEY PRODUCE WHEN ADMINISTERED TO NORMAL ADULTS.

1. ETHER.

Properties.—Pure ether is a colourless, highly volatile, inflammable liquid of specific gravity ·720. The odour of its vapour, although not very pleasant, is more agreeable than that of the "pure methylated ether" often employed. The latter drug produces greater irritation to the air passages, is required in larger quantities to produce anæsthesia, and is more often followed by nausea and vomiting than the pure ether which should always be employed. The vapour of this anæsthetic being inflammable, care should be taken not to bring an artificial light or a cautery near vessels containing ether, or near the mouth of a patient who is fully under the influence of ether. It must be borne in mind that the temperature of the room in which the administration is being conducted materially influences the rapidity with which ether evaporates, it being more difficult to quickly anæsthetise a patient with ether in cold than in hot weather.

Effects of Inhalation.—Assuming that ether vapour is

gradually given, the effects which it produces will be found to be largely dependent upon the degree to which air is allowed to enter the lungs with the vapour. When ether is administered by means of a cone or towel, so that a copious supply of air is admitted, the anæsthetic may be said to be administered by the "open" method; when ether is given in such a way that the supply of air is limited, as by using a Clover's or Ormsby's inhaler, the "close" method results. When ether is given with a copious supply of air, much irritation in the upper air-passages is produced; the patient frequently experiences a sense of suffocation; coughing occurs; excitement, gesticulation, and struggling are common; and a considerable period may elapse before surgical anæsthesia is reached. Clover was the first to demonstrate the advantages of the close method of inhalation (page 84), and if the administration be conducted strictly in accordance with his directions, coughing, excitement, and struggling will either occur in a very minor degree, or will be wholly avoided, anæsthesia becoming quietly established in from two to five minutes. When surgical anæsthesia has been produced, it will be found that the pulse is full, soft, regular, and somewhat accelerated; the respiration is quickened, and considerably deepened; deep snoring stertor is present; the pupils are dilated in proportion to the depth of etherisation; the muscular system is relaxed, and reflex action for the most part is abolished. Large quantities of ether are sometimes needed before relaxation and loss of all reflex action become established. There are four reflexes to which attention should be directed: viz., movements of the extremities dependent upon the surgical procedure; closure of the eyelid when the conjunctiva is touched; the act of deglutition evoked by mucous or ether vapour; and cough, also the result of the two last-named stimuli. If all these reflex phenomena be absent, the narcosis may be said to be profound. If only moderate anæsthesia be maintained, some of the reflex acts here referred to will occur. Large quantities of ether are, as a rule, necessary in operations about the genito-urinary organs and rectum; otherwise tranquil anæsthesia will not be secured. The order in which reflexes disappear will be found to vary in different subjects. Generally speaking, however, the lid reflex is one of the latest

to disappear, and hence the earliest to reappear when the administration is discontinued. As the patient tends to "come round" the lid reflex usually first manifests itself; then swallowing takes place; then a cough is given, and retching or vomiting often follows. Excitement after etherisation is uncommon.

2. CHLOROFORM.

Properties.—"A limpid, colourless liquid, of an agreeable ethereal odour and sweet taste; dissolves in alcohol and ether in all proportions: specific gravity 1·497" (B. P.). Care should always be taken to employ the purest chloroform. Unlike ether, chloroform vapour is not inflammable.

Effects of Inhalation.—Chloroform vapour is by no means unpleasant to inhale when gradually administered with a copious supply of air. When thus given, chloroform vapour is far less irritating than that of ether, and hence coughing and other evidences of irritation are usually absent. Some tinnitus and other unpleasant sensations are occasionally experienced; but, generally speaking, the patient, if not frightened by surroundings, or by too strong a vapour, passes into a dreamy state, in which, although consciousness to a great extent remains, pain is not appreciated. This analgesic effect of small quantities of chloroform is taken advantage of during labour, and as the main element of danger from chloroform—viz., too strong a vapour and too little air—is absent, the mortality under chloroform thus administered is practically nil. As the administration proceeds, consciousness becomes gradually destroyed. There is nearly always a period of some excitement similar to that produced by ether when given by the open method. Reflex action is at this stage still perfect, so that the patient may move or shriek if the operation be commenced, although, as memory, volition, and intelligence have been destroyed, he will preserve no recollection of any such procedure. Tonic spasm, associated with temporary embarrassment of respiration, often arises about this period; but as reflex action passes away the respiration becomes tranquil and regular. The stage of surgical anæsthesia is now commencing, and if the administration be cautiously continued the following signs manifest themselves: The pulse is fuller than when the

administration commenced (chloroform acting, for a while, as a cardiac stimulant); the respiration is regular, and usually somewhat stertorous; the pupils are moderately contracted; the muscular system is relaxed, and the cornea insensible to touch. Much that has been said concerning etherisation applies to the administration of chloroform. One very important difference, however, deserves emphasis: with ether it is possible, almost with impunity, to pass beyond the realm of reflex action, and to keep up an unnecessarily deep narcosis; but with chloroform this is not the case, an overdose being likely, with but little warning, to set up the most alarming symptoms.

3. NITROUS OXIDE.

Properties.—Nitrous oxide is, at ordinary temperatures and pressures, a colourless gas of somewhat sweetish odour and taste. It is supplied by the instrument-makers in a liquid state in iron or steel cylinders, in which it exists, at 60° Fahr., at a pressure of about 1,000 lbs. to the square inch (Barth & Co.). Cylinders containing liquefied nitrous oxide have labels upon them stating the weights of the full and empty cylinders; fifty gallons of nitrous oxide gas thus liquefied weigh fifteen ounces.

Effects of Inhalation.—When nitrous oxide is administered by means of a face-piece possessing valves, so that the expired gas is not re-breathed—when care is taken to prevent the admixture of atmospheric air—when the gas is supplied to the patient equably, and as near as possible at atmospheric pressure—and when the patient breathes, as he should be instructed to breathe, deeply and freely, the following effects are usually produced: a pleasant sensation is experienced throughout the body—a "thrilling," as Sir Humphrey Davy expressed it—and a desire to breathe more deeply arises. If full draughts of the nitrous oxide be inhaled, the sense of suffocation sometimes complained of will not be experienced. An analgesic state is reached before consciousness is actually lost. Very soon, however, anæsthesia ensues, and rapidly deepens. The florid colour of the patient's lips and cheeks becomes replaced by lividity, or cyanosis, proportionate to the previous colour and to the degree to which the anæsthetic is

pushed. Respiration is deepened and usually quickened by nitrous oxide, and after a variable though short period (thirty to sixty seconds) it becomes stertorous and irregular in rhythm. The rate of the pulse is increasingly accelerated throughout, and if the administration be pushed to its full extent the volume of the pulse diminishes. The pupils usually dilate. Muscular movements, both clonic and tonic, are very common, more especially in children, but they do not always occur even when the administration is pushed to its fullest extent. When stertor and clonic movement occur, the administration must be discontinued, otherwise respiration will not proceed. Micturition is liable to occur in children under the influence of the gas. In dental operations the available period of anæsthesia after the removal of the face-piece bears a sort of proportion to the length of time taken to produce full anæsthesia. Under ordinary circumstances this period is of about thirty seconds' duration.

4. MIXTURES OF ANÆSTHETICS.

(I.) *Nitrous Oxide and Ether.*

This is the most valuable combination of anæsthetics with which we are acquainted. It is valuable because the anæsthesia of nitrous oxide may be prolonged by adding ether vapour when the patient has become unconscious from the gas; and also because, by giving nitrous oxide before ether, the former agent prevents all the unpleasant initial effects which would be produced by the latter. Nitrous oxide may either be followed by a small quantity of ether, for brief operations; or by a considerable quantity for more prolonged cases. The effects produced by the combination will chiefly depend upon—(*a*) the degree to which nitrous oxide anæsthesia is carried before ether is admitted; (*b*) the quantity of air allowed during the transition from nitrous oxide to ether; (*c*) the strength of the ether vapour added to the nitrous oxide; and (*d*) the rapidity with which the ether vapour is admitted whilst nitrous oxide is being breathed. Nitrous oxide is irrespirable beyond a certain limit, and hence air must be admitted during the transition to deep etherisation (page 89), otherwise respiration will not proceed satisfactorily.

(ii.) *The A. C. E. Mixture.*

This consists of the following ingredients:—

		Sp. Gr.	Parts.
Pure Ethylic Alcohol	...	·795	1
„ Chloroform ...	...	1·497	2
„ Ethylic Ether	...	·720	3

It is very important that the bottle containing the mixture should have an accurately fitting stopper. It is best to make the mixture in small quantities (about six ounces) at a time. The vapour of the A. C. E. mixture is the most agreeable of all the anæsthetic vapours. It has a fruity odour, and, if largely diluted with air, is very pleasant to inhale. It has been urged that as the constituents of the mixture evaporate at different rates, such constituents will be breathed in a different proportion to that intended. This objection holds good if a considerable quantity of the mixture be placed in an inhaler and the vapour administered. But if very small quantities be added to the mask or cone from time to time, such an objection almost ceases to exist. The A. C. E. mixture should be regarded as diluted chloroform, and administered as though it were that anæsthetic. It is a most valuable and agreeable agent, and is very suitable under certain conditions. When nitrous oxide is not procurable, or when it is probable from the appearance of the patient that difficulties may arise in employing this gas before ether, the A. C. E. mixture may with much advantage be used as a preliminary to etherisation.

The earlier effects produced by the inhalation of this mixture will depend upon the quantity placed in the inhaler and the degree to which atmospheric air is admitted. If administered as directed on page 90, anæsthesia usually becomes established in from four to ten minutes. As compared with chloroform narcosis, that of the A. C. E. mixture has distinct advantages. Conspicuous among these is the stimulating effect upon the heart. Respiration is a trifle deeper and quicker than under chloroform, a somewhat important fact seeing that any change in breathing is more quickly detected. Vomiting is far less common after this anæsthetic than after ether, and about as frequent as after chloroform.

(iii.) *Chloroform and Alcohol.*

Chloroform may with advantage be diluted with pure ethylic alcohol (one-eighth to one-fifth), and the mixture thus made administered as if it consisted of undiluted chloroform. The so-called "bichloride of methylene" is in all probability a mechanical mixture of chloroform with one-fifth of methylic alcohol. These mixtures are, *cæteris paribus,* safer than chloroform itself.

(iv.) *Morphine and Chloroform.*

After even a small dose of morphine (*e. g.*, one-sixth grain subcutaneously), chloroform readily and rapidly produces anæsthesia, but the greatest caution is requisite in maintaining the narcosis. Very little chloroform is required under such circumstances. The respiration must be watched with the utmost vigilance, for it is liable to become enfeebled from the combined effects of the drugs. It is usually possible, after once anæsthesia has been produced, to maintain an analgesic effect by giving but a few whiffs of chloroform vapour occasionally. Great caution is required, and there are many who regard the combined administration as dangerous. Similar caution is requisite in giving morphine to a patient deeply under the influence of chloroform or ether; signs of returning consciousness should be allowed to manifest themselves before the morphine is given.

CHAPTER II.

Modifications in the Effect of the Anæsthetic dependent upon Physical Condition, etc.

1. **Age.**—In infants and very young children ether produces much irritation to the delicate respiratory passages, and the A. C. E. mixture should be preferred. Chloroform and the A. C. E. mixture are well borne in aged subjects, and, generally speaking, these anæsthetics should be employed in such cases. Ether is usually considered to be contra-indicated in old age, but if it be properly administered, and more especially if it be preceded by the A. C. E. mixture, to prevent its initial effects, it is surprising how well it is often tolerated, even by patients of eighty or ninety years of age.

2. **Temperament.**—Hysterical patients sometimes give some trouble, more especially with chloroform, or with ether when administered with a copious supply of air: hence nitrous oxide, followed by ether, is the best anæsthetic in such cases. Patients of a placid, equable temperament take anæsthetics well; excitable people, and those whose nervous systems seem overstrung, are more liable to cause delay in the production of anæsthetic sleep.

3. **Obesity—Plethora.**—Generally speaking, patients of this group do not take ether well, and the greater the exclusion of air during etherisation, the greater the difficulty in the administration. Very stout, flabby patients, who are not full-blooded, are better subjects than the plethoric. In the latter the tongue and mucous membranes of the upper air-passages become much engorged, and render respiration difficult. This vascular engorgement, and consequent swelling, deserve more attention than they have received. The difficulty in breathing which they produce is not encountered in sparely built and anæmic subjects, and would hence appear to be apparently connected in

some way with the quantity of blood present in the body. It would seem that etherisation, more especially when conducted with a limited supply of air (Clover's method), produces engorgement of the right side of the heart and venous system generally: that this venous engorgement is most marked in persons of an apoplectic type; and that in such patients the upper air-passages (mouth, nose, etc.) are liable to become diminished in size, or occluded, by such swelling. In the transition from nitrous oxide to ether the difficulty here referred to is likely to occur, and hence it is a good plan not to use this combination in such subjects, or, if it be used, care should be taken to prevent any difficulties in breathing by the preliminary insertion of a small mouth-prop between the teeth. Plethoric patients may usually be satisfactorily anæsthetised by the A. C. E. mixture, followed by ether gradually administered from an Ormsby's inhaler.

4. **Asthenia—Collapse—Anæmia.**—Patients of this class require but small quantities of any anæsthetic. The characteristic stertor of nitrous oxide anæsthesia may be replaced by shallow respiration, and care must be taken not to push the administration unduly. The same is more or less true of other anæsthetics. Deprivation of air is very badly borne by these patients, and hence ether must be administered with plenty of air. When much blood has been lost upon the operating table, or in lengthy operations upon extremely feeble subjects, it is better to allow the patient to occasionally exhibit symptoms of imperfect anæsthesia than to unnecessarily push the anæsthetic.

5. **Habitual and excessive use of Alcohol, Tobacco, Morphine, Chloral, etc.**—Patients addicted to these excesses frequently give some trouble. A transitory and imperfect anæsthesia from nitrous oxide is liable to arise, and with ether or chloroform the stage of excitement is often prolonged. As the excessive use of alcohol and tobacco is frequently associated with a plethoric habit, the phenomena referred to in Section 3 may be superadded.

6. **Diseases of the Heart and Blood-vessels.**—Patients with morbus cordis take anæsthetics well as a general rule. But if the heart have undergone extensive degenerative changes much care will be needed. Nitrous oxide and

also ether are badly borne if the cardiac affection is associated with cyanosis and extensive pulmonary changes (œdema, hydrothorax, etc.). The A. C. E. is an excellent anæsthetic for most cases of advanced cardiac disease, and undiluted chloroform should be avoided if possible. Patients who are the subjects of extensive atheroma should not be anæsthetised with ether, as there is risk of cerebral hæmorrhage. The A. C. E. mixture or chloroform diluted with alcohol will be found to answer well.

7. **Affections of the Air-passages or Pleuræ attended by Dyspnœa or Cyanosis.**—Generally speaking, ether is best avoided in such cases as these; and the A. C. E. mixture should be employed. If, however, the last-named anæsthetic should cause any additional distress in breathing, chloroform (preferably diluted with alcohol) must be given.

8. **Cerebral Affections attended by Impairment of Consciousness.**—Much care is needed in anæsthetising patients who are already more or less unconscious. When coma is present to a greater or less degree, no anæsthetic, or only the smallest quantity, will be required. The risk of giving morphine before the administration of the anæsthetic is greater in these patients than in those whose cerebral functions have not been impaired by disease.

CHAPTER III.

PREPARATION OF THE PATIENT FOR THE ADMINISTRATION OF THE ANÆSTHETIC.

THE best time for the administration of nitrous oxide is about three hours after solid food has been taken. With ether, chloroform, and other anæsthetics, five to six hours should have elapsed after solid food, but a little clear soup, with or without a glass of wine, may, in the case of feeble patients, be allowed about three hours before the actual administration. Eggs and milk should be withheld. A small quantity of brandy, with a little less than the same quantity of water, may be given to patients whose circulation is feeble, immediately before the administration—a plan more especially to be recommended when chloroform is to be employed. Artificial teeth should always be removed. The position of the patient should be as comfortable as circumstances will allow. Whenever it is possible, the anæsthetist should ask his patient to lie in that position which he assumes on retiring to rest at night. If convenient to the operator, the head should be kept on the side—a point of great importance if vomiting be likely to arise, as in operations of emergency, intestinal obstruction, &c. The clothing should always be loose, even during the administration of nitrous oxide for a momentary and simple operation. Stays and waistbands should be loosened or removed, in order that respiration may be freely performed.

CHAPTER IV.

THE SELECTION OF THE ANÆSTHETIC.

THE selection of the anæsthetic should be regulated by:—1. The condition of the patient; 2. The nature and length of the operation about to be performed.

In every case the chloroformist should carefully observe the kind of patient entrusted to his care; he should notice how respiration is performed—more especially whether nasal respiration is present or not; and he should invariably feel the pulse before commencing his duties. With nitrous oxide a stethoscopic examination of the chest is unnecessary, unless it is obvious from an inspection of the patient, or from other indications, that some intra-thoracic affection exists. With other anæsthetics it is usually a good plan to listen to the chest; but no prolonged stethoscopic examination need be resorted to unless special indications exist.

Generally speaking, nitrous oxide is the best anæsthetic for very brief operations; and ether for longer cases. As already mentioned, the disadvantages connected with the latter anæsthetic may to a great extent be removed by preceding the inhalation by nitrous oxide or the A. C. E. mixture. There are of course many cases in which neither nitrous oxide nor ether should be given; and the following table has been drawn up to show these exceptions.

Cases suitable for the A. C. E. mixture.	Cases suitable for Chloroform. (1)
Infants and very young children. Most patients above 60 or 65 years of age. (2) Extreme obesity, especially if associated with plethora. (2) Most cases of advanced cardiac disease. Affections of the air passages or pleuræ, attended by dyspnœa or cyanosis.	Prolonged nasal or oral operations (3), and those with the actual cautery. Cases in which neither ether nor the A. C. E. mixture is well borne. Labour. Marked atheroma.

Note on Abdominal Section : operations upon or near large vessels, &c.

There are cases in which the venous engorgement of ether might constitute a serious difficulty or danger, *e.g.*, in the removal of glands at the root of neck, tracheotomy, the ligature of large arteries, &c. In these cases the A. C. E. mixture or chloroform is, from the point of view of the operator, preferable to ether. Again, in abdominal section, chloroform undoubtedly possesses, so far as the performance of the operation goes, advantages over ether; for the respiration is more tranquil, the engorgement of the parts is less, and there is less liability to cough. Whether the advantages referred to should be allowed to outweigh the one great advantage of ether—its greater safety—is a matter of opinion.

([1]). Chloroform may with advantage be diluted with a small quantity of alcohol (page 77).

([2]). It is often a good plan in these cases to commence with the A. C. E. mixture and to continue with ether from an Ormsby's inhaler, taking care not to deprive the patient of air to too great an extent.

([3]). It is an excellent practice to place the patient deeply under ether, and subsequently to maintain the anæsthesia by chloroform administered through the nose or mouth by means of Junker's apparatus.

the ether. When the indicator is at "3," three-quarters of the current are diverted. When the indicator is at "F" (full), four-quarters, or the whole, of the current is made to pass over the ether as it travels between the face-piece and the bag.

Method of using the Inhaler.—(1) In cold weather, and when about to anæsthetise powerfully-built subjects, place the ether-chamber in warm water for three or four minutes. (2) Throw out any water that may have entered, and pour into the sphere, by the tube provided for the purpose, about an ounce and a-half of ether. (3) Turn the indicator to "O." (4) Accurately but gently adapt the face-piece, during an expiration, to the face of the patient; by pressing it a little more tightly during expiration than during inspiration the bag will become distended with expired air. (5) Allow the patient to breathe to and fro for about half a minute. (6) Very gradually rotate the ether-chamber, so that the "O" on the apparatus moves gradually, about one-eighth of an inch at a time, away from the indicator. (7) Should swallowing or coughing arise, turn back somewhat till these signs of irritation have subsided. (8) Should excitement or struggling occur, do not discontinue the administration. (9) When the cheeks and ears tend to become dusky in colour, admit a breath of fresh air by removing the inhaler, and gradually increase the strength of the vapour, remembering that the more air admitted the more ether must be given in order to secure deep anæsthesia. (10) As a general rule, the inhaler should be removed every fourth or fifth respiration for a breath of fresh air; this rule will, however, require modification in the earlier and later stages of the administration; in the earlier stages it will usually be found advantageous to give somewhat less air than that indicated, in the later stages the inhaler need only be applied occasionally. (11) When once surgical anæsthesia has become established the indicator may be kept at "1" or "2," except in the case of very strongly built or alcoholic subjects who require considerable quantities of the anæsthetic. (12) Watch respiration carefully and the pulse occasionally; should the breathing become feeble or shallow, or the pulse weak, as it might become in extremely feeble patients, the

anæsthetic should be discontinued till these symptoms have passed off.

Ormsby's Inhaler, which consists of a face-piece and bag, between which there is a sponge for the reception of the ether, although simpler in construction, possesses some disadvantages as compared to Clover's apparatus. About one ounce of ether should be poured upon the sponge, and the inhaler should be very gradually applied to the face, otherwise much coughing and irritation will result. More ether is used than with Clover's inhaler, and the depth of etherisation cannot be quite so satisfactorily regulated as with the latter apparatus. Ormsby's inhaler may, however, be employed with advantage for rapidly inducing etherisation after nitrous oxide, the face-piece employed for the latter agent being quickly replaced by the ether inhaler; and it is equally useful when, after having administered a small quantity of the A. C. E. mixture on an open inhaler, it is wished to keep up the anæsthesia by means of ether.

The **simple felt cone,** with a sponge at its apex, is to be recommended for use in those cases which require very little ether and a very copious supply of air.

2. CHLOROFORM.

One of the best inhalers for the administration of chloroform is Junker's (Fig. 17). It consists of a graduated bottle for the anæsthetic, hand-bellows and tubes for pumping air through the chloroform, and a face-piece for the reception and transmission to the patient of a chloroform vapour well diluted with air. The bottle for the anæsthetic is suspended by a hook from the coat of the administrator. About six drachms of chloroform (chloroform and alcohol, or "bichloride of

Fig. 17.—JUNKER'S INHALER.

methylene") are placed in the bottle; the face-piece is brought near the face; gentle pressure is made upon the hand-bellows; and thus air containing chloroform vapour is administered to the patient. It is said that, at a temperature of 55° Fahr., and with one ounce of chloroform in the bottle, not more than one and one-fifth minim of chloroform is vapourised by a single compression of the bellows. With undiluted chloroform anæsthesia becomes established in from four to ten minutes. When once the stage of surgical anæsthesia has been reached vigilance must be exercised, for unlike ether, chloroform tends to set up symptoms of respiratory and cardiac depression if the anæsthetic be incautiously administered. The chief objection to Junker's apparatus is that it is somewhat difficult to watch the pulse whilst employed in pumping the bellows and holding the face-piece; but if the head of the patient be kept upon the side, the face-piece may be retained in position by means of a loose towel beneath it, and thus one hand of the administrator will be free. By the employment of a flexible metal tube instead of a face-piece, anæsthesia may be efficiently maintained during operations about the mouth or nose, *e.g.*, in staphyloraphy, removal of tongue, &c., or the indiarubber tube of Junker's apparatus may be attached to a special form of gag, possessing small metal tubes to convey the chloroform vapour to the back of the mouth during such operations (Hewitt's gag).

Chloroform is very commonly administered by dropping or pouring small quantities at a time on a folded towel or piece of lint. When administering the agent without any special apparatus, a drop-bottle should be used. The accompanying figure represents a simple mask (known as Skinner's) and a drop-bottle for the chloroform (Fig. 18). For the safe employment of this method all hurry must be avoided; three or four drops of chloroform should

Fig. 18.—SKINNER'S MASK AND CHLOROFORM DROP-BOTTLE.

at first be given; in a few seconds five to ten more; when the odour of the chloroform has nearly passed off five to ten drops more may be added, and so on. Children require smaller quantities than these. Care must be taken not to employ a saturated piece of lint or flannel; and a copious supply of air is imperatively necessary throughout.

In whatever manner chloroform is administered, the anæsthetist must be careful not to push the anæsthetic when deep respirations accompany or follow the stage of excitement, for it is then that an overdose is most likely to be given; and it is a good plan, when signs of surgical anæsthesia commence to appear, to discontinue the administration for a moment or two, and allow a few respirations of air to be taken before proceeding with the inhalation. The pulse must be watched throughout, as it frequently gives the first indication of danger. The respiration should be listened to, and the colour of the lips and ears observed. Stertor should not be allowed to become too deep. The pupils, which are moderately contracted when surgical anæsthesia is satisfactorily established, should be looked at from time to time.

3. NITROUS OXIDE.

In administering nitrous oxide it is advisable to employ two cylinders of the liquefied agent, so that should one fall

Fig. 19.—CYLINDERS FOR NITROUS OXIDE.

short, or fail to work during the administration, the other may at once be turned on (Fig. 19). By rotating the foot-key, nitrous oxide gas is liberated and made to pass through a small indiarubber tube to a bag, from which it may be inhaled by means of a face-piece and stopcock. The accompanying drawing (Fig. 20) shows the most convenient arrangement for the purpose, the inspiratory and expiratory valves, which

are necessary in order to prevent re-breathing of the gas, being placed in the stopcock. As arranged in the figure, air would be breathed through the apparatus as indicated by the arrows; but if the handle H be moved round, nitrous oxide will be inhaled from the bag and escape from the expiratory valve shown above. In administering the gas the following brief directions should be attended to:—(1) If the operation is to be within the mouth, a small "prop" should be inserted between the teeth; (2) The bag should be half-filled with gas; (3) The face-piece should be *very accurately* applied to the face; (4) Air should first be breathed through the apparatus; (5) The patient should be instructed to breathe freely and deeply, and, whilst he is thus breathing air through the apparatus, nitrous oxide should be turned on; (6) The bag should be kept nearly full throughout the administration; (7) When signs of nitrous oxide narcosis occur the face-piece should be removed or air otherwise admitted.

Fig. 20.—NITROUS OXIDE APPARATUS.

4. MIXTURES OF ANÆSTHETICS.

Nitrous Oxide and Ether.—There are several ways of administering these anæsthetics together, and space will not permit a description of them. Whatever plan is chosen, it will be found advisable to freely administer nitrous oxide before ether is admitted, and to pay a due regard to the necessity of allowing a small quantity of air whilst proceeding from nitrous oxide anæsthesia to that of ether. If no air be allowed, respiration cannot continue; if too much be given, the patient will recover from the effects of the gas, and so the very purpose for which the latter was administered will be defeated. Clover's gas-and-ether apparatus is employed by some; others prefer to pass nitrous oxide through Clover's portable regulating inhaler, and to turn on ether whilst nitrous oxide is being inhaled; and, lastly, there are

advocates for the plan of first administering nitrous oxide by the ordinary means, and rapidly changing the gas apparatus for a previously charged Ormsby's ether inhaler.

The A. C. E. Mixture.—This mixture should be administered in small quantities at a time, with a copious supply of air. A Skinner's mask will suffice for children, and for weakly adults; but in the case of stronger persons some kind of felt or leather cone, provided with a small sponge, and permitting a free supply of air, will be necessary. The quantity of the mixture which should be added at one time should be regulated by the age and strength of the patient. With children and feeble persons, sprinkling from a drop-bottle upon the mask or cone will be sufficient; but with more vigorous individuals half-drachm doses will be required to secure satisfactory anæsthesia. It is a bad plan, and one likely to be followed by evil consequences, to place a large quantity of the mixture at one time within an inhaler, for the objection to anæsthetic mixtures would thus at once apply. Nor should a Clover's or Ormsby's inhaler be used, for air limitation with chloroform, or any mixture containing chloroform, is to be deprecated. The administration should be maintained as if chloroform were being employed, though, of course, a considerably larger quantity of the A. C. E. mixture than of chloroform will be required to produce anæsthesia. As with chloroform, plenty of time (five to ten minutes) should be taken in establishing surgical anæsthesia.

Chloroform and Alcohol ("Bichloride of Methylene").—Mixtures of chloroform and alcohol should be administered in a similar manner to chloroform. It may be as well, however, to point out that, with Junker's inhaler, difficulty may sometimes be experienced in anæsthetising by means of chloroform diluted with as much as one-fifth or so of alcohol, except in the case of children. The so-called "bichloride of methylene," which appears to consist of chloroform diluted with methylic alcohol, should be administered with all the care and precaution which are essential in giving undiluted chloroform.

CHAPTER VI.

The Chief Difficulties and Dangers connected with the Anæsthetic State—their Management and Treatment.

The administrator should have at hand the following appliances and remedies in case of need:—Tongue forceps, Mason's gag, nitrite of amyl capsules, brandy, liq. ammon. fort., a hypodermic syringe, and instruments for tracheotomy. In mouth operations he should also have several sponges, firmly fixed in strong sponge-holders.

However skilful the administrator may be, he will be certain to meet with difficulties from time to time, and he should therefore ever be on the alert, even in cases which appear to be of the most simple nature. Very nervous patients require encouragement, and should be instructed how to inhale the anæsthetic. Should excitement or struggling occur under nitrous oxide or ether, the anæsthetic may unhesitatingly be pushed; but with chloroform, or the A. C. E. mixture, much caution is requisite at this stage, and a very copious supply of air must be allowed. It is best not to restrain the patient's movements, unless there is a fear of his injuring himself, or interfering with the administration. Coughing and swallowing in the very early stages point to too strong a vapour, and they should be met by a diminution in the strength of the anæsthetic. Should they tend to arise, however, after surgical anæsthesia has become established, they should be met by increasing the strength of the vapour as quickly as the circumstances will permit. Vomiting, which will not take place if the anæsthesia be profound, is, practically speaking, always preceded by acts of deglutition, and when such acts occur the depth of the anæsthesia must at once be increased if it be desired to avert vomiting. With ether there is no danger in thus rapidly producing deeper narcosis;

but this cannot be said so confidently of chloroform. Difficulty is sometimes experienced in producing full surgical anæsthesia, some patients requiring very large doses of the anæsthetic before perfect quietude is secured. Should this occur with nitrous oxide, the admixture of a small quantity of air, by the side of the face-piece or elsewhere, may be suspected. It is well known that many fatalities have occurred with chloroform during or immediately after the stage of excitement, the explanation being that the patient, having had but little air for some moments, by reason of the breath having been held, inhales with the following deep respirations a large quantity of chloroform, and as the inhalation of chloroform during even a minor degree of asphyxia is highly dangerous, serious consequences may follow. Should it be found difficult to secure full surgical anæsthesia with ether, a sponge wrung out of hot water may be applied to the sides of Clover's inhaler, in order to get a sufficient quantity of ether evaporated, and air should be sparingly admitted for a time, unless contra-indications exist. Just as there are patients who require large doses of an anæsthetic, so there are others who display an opposite peculiarity. The weaker and more fragile the patient, the more rapidly will the anæsthetic produce its effects. Anæmic and debilitated individuals, more especially if advanced in years, will be found to exhibit very different effects from those which have been described as taking place in healthy and vigorous subjects.

Respiration should be carefully listened to from the commencement to the end of the administration. Whenever it is difficult to hear the breathing the administrator should, by other means, make certain that it is proceeding in a satisfactory manner, bearing in mind the fact that movements of the chest and abdomen will continue for a time if the air-way is completely obstructed. It is important that the anæsthetist should recognise the two distinct ways in which respiration may fail during anæsthetic sleep. It may fail—(1) in consequence of some mechanical impediment to the entry and exit of air; or (2) independently of any such obstruction in the air-way, *i.e.*, from feebleness or paralysis of the respiratory mechanism.

Obstructive Respiratory Failure.—When it is obvious that

there is some obstruction to breathing, we must at once endeavour to discover the cause. An adventitious substance may be present—mucus, blood, pus, vomited matters; a purely anatomical reason may exist—the tongue, or epiglottis, may, by reason of the position of the head or lower jaw, be in contact with the pharynx; such a degree of vascular engorgement and swelling of the tongue or other parts in the uppe air-passages may have arisen as to prevent the proper entry of air; or, lastly, laryngeal spasm from too strong a vapour or other causes may have been produced. To carefully maintain a free air-way is of paramount importance. With regard to blood, vomited matters, &c., entering the larynx, the administrator should, whenever there is a possibility of this occurring, strive to keep the patient's head well turned to the side, and to remove all blood, &c., from the back of the throat by repeated sponging. In operations in or about the mouth or nose, accompanied by free hæmorrhage—*e. g.*, removal of the superior maxilla—the position indicated should be carefully maintained, if convenient to the operator; or the head should be thrown very far back over the edge of the table. In the removal of post-nasal adenoids by means of the "artificial nail," it is a good plan to put the patient under ether, gently raise him to the sitting position, and keep the head and shoulders well forward during the operation, so that blood, &c., may freely drain away through the mouth and nose. In all mouth and nose cases, with free hæmorrhage, anæsthesia should never be very profound, except, perhaps, just at first; coughing and swallowing should be allowed to occur occasionally, and the operator should not object if the unconscious patient is a little restless at times. In connection with the anatomical conditions which may obstruct breathing, these may usually be easily removed, either by throwing the head well backwards, thus removing the back of the tongue and the epiglottis from the pharynx and larynx; or pushing the lower jaw forward, which has the same effect and is more easily done; or by placing a small mouth-prop between the teeth, if nasal respiration be inadequate; or by separating the lips of edentulous patients, &c. Should it be found, prior to the operation, that nasal obstruction is present, the anæsthetist should insert a small mouth-prop between the

teeth before commencing the administration; and he may with advantage adopt a similar precaution in the case of plethoric, short-necked patients, who, as already explained, are liable, more especially under ether, to suffer from transient difficulties of respiration. Loud snoring is often due to a swollen tongue, which vibrates against the pharynx, and when it occurs it is advisable to keep the lower jaw pressed well forward, in order to prevent obstructed breathing. With all anæsthetics it will be found a good plan to adopt a similar course, should any tendency to embarrassed breathing arise. Laryngeal spasm, which is known by high-pitched crowing respiration, often results from too strong a vapour, and is to be met by withdrawing the anæsthetic till the spasm has passed off. It may, however, be the reflex result of certain operative procedures during moderately deep anæsthesia, and may lead, under chloroform, to circulatory depression in a short space of time. Uterine, pelvic, and rectal operations are the most likely to initiate this condition, and hence deep anæsthesia is always advisable in such cases. Should the above-mentioned manœuvres fail to relieve the obstruction which is present, the mouth should at once be opened, and the tongue pulled forcibly forward, when breathing will almost certainly recommence. If, however, respiration does not take place, forcible pressure upon the chest should be made, with the object of overcoming any obstruction in or about the larynx. If air cannot thus be forced out of the chest, any further attempt at artificial respiration will probably be useless. Still, the arms may be extended once or twice by Silvester's method, and if no beneficial result follow, tracheotomy should be performed, and artificial respiration at once commenced. No attention need be paid to the pulse when respiration obviously fails in consequence of some obstruction; otherwise delay in overcoming the obstruction will arise.

Non-obstructive Failure of Respiration.—The other form of failure of respiration is of a wholly different nature, for it occurs independently of any obstruction, and is characterised by a more or less gradual cessation of all thoracic and abdominal respiratory movements. Although such failure usually proceeds from feebleness or actual paralysis of the nervous mechanism of respiration, other factors are sometimes present.

For example, the bony framework of the chest may, from senile or other changes, fail to respond in a satisfactory manner to the demands made upon respiration; or the respiratory muscles may be weak and similarly unfitted for any unlooked-for exertion; or lastly, by reason of pre-existing pulmonary or pleural disease, the performance of the necessary respiratory movements may become a matter of difficulty or even impossibility. Respiratory failure of this kind is most common under chloroform, though it may arise under nitrous oxide or ether. It usually co-exists with feeble cardiac action and low vascular tension, sometimes being apparently dependent upon these conditions, as for example in the case of shock from loss of blood and other causes. Syncope occurring upon the operating-table and arising from one or other of the conditions to be presently described may, if the administrator be watching the breathing, first show itself by feeble respiration. With regard to the direct effects of anæsthetics upon respiration, the late Hyderabad Commission have shown that chloroform, when administered to the lower animals in toxic doses, lowers vascular tension and paralyses respiration, the action of the heart continuing after actual cessation of breathing has taken place. It is urged by the Commission that this sequence of events occurs in the human subject; and it is probable that, when respiration ceases *purely from the direct effects* of chloroform, the heart may continue beating, though feebly, for a brief space of time. The practical conclusion arrived at by the Hyderabad Commission is that when administering chloroform the whole attention should be directed to respiration and that the pulse should be disregarded. As will be presently shown, however, the pulse may often give very early indications of impending danger, and for this reason should be carefully watched in administering chloroform. Shallow or imperceptible breathing, with cyanosis, is nearly always associated with an extremely feeble pulse, but this combination of symptoms is much more pronounced under chloroform than under ether. If ether be administered to a poisonous extent, gradual failure of respiration will occur; but, by reason of the stimulant effect of ether upon the heart, the patient may nearly always be rescued by artificial respiration. The first remedy which should be applied in all these cases

is artificial respiration, commenced by a compression of the thorax. In minor cases, after two or three compressions, breathing will recommence, and may be further stimulated by flicking the chest with a wet towel, or by briskly rubbing the lips and cheeks of the patient with a dry cloth. If, however, this should not be the case, systematic artificial respiration by Silvester's method should be resorted to, and sedulously maintained, even though the threatening symptoms were originally cardiac. Whilst artificial respiration is thus proceeding, nitrite of amyl may be applied to the nostrils, and other remedial measures appropriate in syncope may be resorted to if deemed advisable. The tongue forceps need not be used if it is obvious that a free air-current to and from the chest exists; but care should of course be taken to maintain this free air-way during artificial respiration. The latter should be continued for at least an hour, or for longer if any signs of animation can be detected.

Cardiac Failure.—The circulation may become enfeebled or actually arrested during the administration of an anæsthetic. Generally speaking, the weaker the patient the more likely will the heart be to show signs of failure. Putting aside morbid cardiac and pulmonary conditions, there is clinical evidence to show that failure of the heart during anæsthesia may arise in at least four ways: viz., (1) reflexly; (2) during incidental asphyxia; (3) from loss of blood or other exhausting influences; and (4) as the result of an excessive dose of the anæsthetic. Temporary reflex arrest of the heart's action may take place under all anæsthetics, more especially, it is said, if the anæsthesia be not profound. The severer cases of reflex syncope would seem, however, to be met with chiefly, if not exclusively, under chloroform. With regard to the asphyxial element during anæsthesia, it may be said that under chloroform the deprivation of air even in a minor degree may be followed by serious cardiac depression; whereas with ether, unless the patient be much exhausted, a moderate limitation of air is not likely to be attended by evil consequences. We may speak of the cardiac depression which may thus be induced as "asphyxial syncope"—a condition which would seem to depend upon an over-distension of the right cavities of a feebly-acting heart. With reference to cardiac failure

occurring in persons exhausted by loss of blood, in prolonged exposure upon the operating-table, and in patients weakened by previous disease, little need be said, as the symptoms are usually independent of the anæsthetic. The question as to the direct effect of chloroform upon the heart is too complex to be satisfactorily discussed here. It may be said, however, that it is now established as a fact that, in the lower animals, final arrest of the heart from an overdose of chloroform is always secondary to respiratory failure. With reference to nitrous oxide, and to ether, when administered in poisonous doses, there can be little doubt that the cardiac movements continue till after respiration has ceased. Chloroform, however, undoubtedly lowers the action of the heart after a temporary stimulation, and predisposes, so to speak, to cardiac depression from a variety of causes. Toxic symptoms of a poisonous overdose of chloroform sometimes manifest themselves so rapidly that it becomes impossible to say when cardiac action ceases. The administrator should accustom himself to observe the pulse as frequently as is practicable, and this is more especially necessary with chloroform. Should it become very feeble, slow, irregular, or intermittent, the anæsthetic must be withdrawn and fresh air freely admitted till improvement occurs. Those who recommend that no attention should be directed to the pulse, but that the respiration only should be watched, are not so likely to obtain early indications of approaching danger as those who keep a sharp look-out for changes in the character of the pulse. In asthenic, cachectic, or hectic subjects, in patients suffering from shock, in fatty degeneration or other advanced affections of the heart, and in persons who have lost a considerable quantity of blood during the operation, the pulse should be carefully watched. As already mentioned, asthenic subjects require very little of any anæsthetic, and are highly intolerant of any deprivation of air. Speaking generally, should the pulse gradually grow weaker and more rapid, the face and lips paler, the extremities colder, the eyelids fail to close—symptoms not infrequently met with in prolonged operations upon weakly subjects, the administrator should be careful not to keep his patient too deeply anæsthetised; he should see that the head is low and that the patient is kept as warm as

possible; and he should of course warn the operator of the patient's condition. If, under such circumstances as these, completion of the operation is urgently called for, an enema (an ounce of brandy to two or three ounces of warm water) may be given with advantage; and cloths wrung out in very hot water may be applied to the head. These measures will usually suffice to tide over the remaining period of the operation. If, however, the pulse should become imperceptible at the wrist, and the pupils dilated, the operation should be discontinued, the head lowered, the legs elevated, a broken capsule of nitrite of amyl or a cloth moistened with a few drops of liq. ammon. fort. held to the nostrils of the patient. It occasionally happens, more especially with chloroform, that symptoms of cardiac depression come on more suddenly than the preceding description would suggest. Under such circumstances the anæsthetist should at once forcibly compress the lower ribs and proceed without delay to artificial respiration by Silvester's method. He should at the same time direct that the legs be raised as much as possible and the head lowered, and a few drops of nitrite of amyl administered. He himself should attend to nothing save the artificial respiration. Cases of moderate severity will usually yield to these measures in a short time; but should this not be the case, artificial respiration must be maintained for at least an hour. Sudden chloroform syncope in children may often be successfully treated by merely inverting the patient, but the inversion should as a rule be supplemented by artificial respiration.

Part III.

LIGATURE OF ARTERIES.

CHAPTER I.

GENERAL CONSIDERATIONS.

History of the Ligature.—The use of the ligature as a hæmostatic dates from the very earliest times.

It was advised by Celsus, who flourished in the first century. "The bleeding vessels," he wrote, "are to be taken up, and two ligatures to be applied, one on each side of the wound, and then to be divided between the ligatures."

It is mentioned by succeeding authors—by Galen in the second century, by Aëtius in the fifth, by Rhazes in the tenth. Each writer quotes the authority of his predecessor, or speaks of the procedure as emanating from Celsus or Galen. In spite of the fact that some writers on medicine and surgery in the eleventh, twelfth, and thirteenth centuries still give an account of the ancient use of the ligature as described by Celsus and his followers, the practice does not appear to have become general. In the sixteenth century at least the securing of arteries by ligature as a practical measure was unknown. The bleeding after amputation was checked by styptics, "agglutinatives," or the actual cautery, and to Ambrose Paré is certainly due the credit of introducing the ligature definitely into surgical practice.

So novel was Paré's proposal that, although he was familiar with the use of the ligature as described by the ancients, he regarded his invention as quite phenomenal. "I think it was taught me," he writes, "by the special favour of the sacred Deity; for I learnt it not of my masters, nor of any other, neither have I at any time found it used by any." This was in the year 1564. This very important element in practical

surgery was very slowly accepted. The great English surgeon, Wiseman, writing more than one hundred years later, recommended the use of a "royal" styptic, or the cautery, in the place of the ligature.

Sharp, writing in 1761, takes pains to especially advocate the use of the ligature for the arrest of bleeding, because "it was not as yet universally practised among surgeons residing in the more distant counties (of England)."

Antyllus, who flourished in the fourth century, is reputed to have treated aneurysm by first ligaturing the artery above and below the tumour, and then evacuating the contents of the sac. He was careful to isolate the vein, and passed the thread by means of a needle directed by a probe.

Anel ligatured the brachial artery in 1710, for a traumatic aneurysm at the bend of the elbow, applying the thread close to the tumour. In December, 1785, John Hunter, after many experiments and careful investigation of the whole subject, ligatured the femoral artery, in what is now known as Hunter's canal, for the cure of popliteal aneurysm.

From this time dates the modern method of treating aneurysm by ligature.

In the early days of the ligature the method known as "mediate ligation" was employed; that is to say, the tissues surrounding the artery were also included in the ligature, and the vessel was thus compressed through the medium of those structures. It was Deschamps who, in 1797, first insisted that the artery should be well and completely isolated before the ligature was tied, and with him must rest the credit of the introduction of the present method of "immediate ligation."

The introduction of catgut as a ligature material, by Sir Joseph Lister, and the employment of antiseptic measures in the treatment of wounds, has greatly modified the dangers of the operation.

The silk ligature was left in place until it had cut through the vessel. Its extremity was allowed to hang out of the wound. It acted as a seton. Primary healing was not possible; and secondary hæmorrhage, and the evils attending suppuration, were quite common.

The use of *animal ligatures*, which could be absorbed in due course and which would introduce no septic influence

into the wound, altered the aspect of the operation. The animal ligature appears to have been first introduced in 1814 by Dr. Physick, of Philadelphia. He used little strips of chamois leather which had been rolled upon a slab until they were hard and round. The ligature was cut short, and was never seen again in those wounds which healed by first intention. These ligatures appear to have been employed in the United Kingdom together with other experimental forms of animal ligature. Sir Astley Cooper tied the femoral successfully with catgut, while Dr. McSweeny, of Cork, recommended silkworm gut. Silk was, however, the regular material employed, until Lister definitely introduced catgut, and established the properties and determined the preparation of that substance.

The materials more recently introduced are ligatures of ox aorta and of kangaroo tendon.

A very valuable contribution to the history of this subject is afforded by Mr. Holmes in the *British Medical Journal* for November 15th, 1890.

Instruments required.—The following is the list:—1, Scalpel; 2, two pairs of dissecting forceps; 3, wound hooks; 4, retractors; 5, long toothed forceps; 6, pressure forceps; 7, aneurysm needle; 8, ligature; 9, artificial light.

1. The scalpel should be small, and of the pattern already described. A stout instrument may be used for the skin incision, a finer for opening the sheath.

2. The tissues are often very conveniently divided between two pairs of dissecting forceps, one pair being held by an assistant.

3. Small blunt hooks, with long shafts, are most convenient as retractors, especially to draw nerves and tendons out of the way. Their use is well illustrated in the operation for securing the lingual artery.

4. Good retractors are needed when deeply-seated vessels are concerned. In securing the iliac arteries especially, broad copper spatulæ and large rectangular retractors are of use.

5. The sheath may be in most cases quite conveniently picked up by ordinary dissecting forceps. In the case of deep-seated arteries, however, longer, finer, and neater instruments

are required, and of these the finely-toothed forceps are the most convenient.

Specially long forceps are needed for securing the iliac arteries.

6. As the wound must be as bloodless as possible, pressure forceps are very necessary. If the bleeding vessel be carefully picked up, and the forceps be allowed to remain long attached, the hæmorrhage will usually be checked without the need of a ligature.

7. The aneurysm needle must be well made and well polished. It need not be too fine. In dealing with large and deeply-placed arteries, a very strong needle is required. In James's case of ligature of the abdominal aorta the needle broke at its handle, the surgeon "little anticipating occasion for so much force." Needles are not infrequently met with made of such indifferent metal that they bend under a not unreasonable strain.

The ordinary needle (Fig. 21), in which the curve is simple,

Fig. 21.—ANEURYSM NEEDLE.

and in which the plane of the handle is at right angles to the plane of the blade, answers very well in most cases. It appears to have been devised by Saviard towards the end of the seventeenth century. The instrument known as Syme's needle

Fig. 22.—SYME'S ANEURYSM NEEDLE.

(Fig. 22), in which the "flat" of the handle and of the steel are on the same plane, is preferred by many.

For not a few deeply-seated arteries the doubly-bent needle of Dupuytren (Fig. 23) is of great service, if not, indeed,

essential. The curved part of the needle is here bent laterally, and is at right angles to the long axis of the handle. There are two forms of this needle—one bent to the right, and the other to the left.

8. The best ligature material on the whole is chromicised catgut. It must be of reliable make, be strong, round, quite lissome, of uniform thickness, and perfectly smooth. The size must be regulated by the dimensions of the vessel to be tied.

Fig. 23.—DUPUYTREN'S ANEURYSM NEEDLE.

There is no especial advantage in the use of very thick catgut. The ligature to be applied should always be selected with great care and well tested.

It should be allowed to soak for ten minutes or so in carbolised water, and should then be again examined and tested. It must be long enough to be easily manipulated. Mr. Holmes prefers a ligature of kangaroo tendon to one of catgut, on the ground that the latter material is not always of quite reliable composition.

Mr. Holmes has given an admirable review of the different forms of ligature in the paper already named.

On the subject of the tendon ligature a paper by Mr. Dent (*Med. Chir. Trans.*, Vol. LXIV.) may also be consulted. (For a consideration of the flat ligature, *see* "Ligature of the Innominate Artery.")

9. In the exposure of deeply-placed vessels a good light in the depths of the wound is essential. This may be obtained by means of a reflector, or, better still, by the use of a small portable electric lamp.

Position of the Patient.—The position of the patient will vary a little according to the artery to be tied. In general terms, it may be said that the surgeon should stand upon the side to be operated on, and that the incision on the right side is more conveniently made from above downwards, and on the left side from below upwards. The chief assistant stands opposite to the surgeon, and has for his principal duty the sponging and the retraction of the parts of the wound.

The Steps of the Operation.—These will be considered in the following order:—

1. The line of the artery.
2. The incision.
3. The exposure of the artery.
4. The opening of the sheath.
5. The passing of the ligature.

1. *The Line of the Artery.*—This line must be very accurately defined. It may differ from what is commonly given as the anatomical line of the vessel.

For example, the course of the ulnar artery is said to be represented by a line drawn from the middle of the bend of the elbow to the radial side of the pisiform bone. This line scarcely touches the artery, however, at any one point. The surgical line for the lower two-thirds of the vessel—the part upon which a ligature may be applied—is represented by a line drawn from the tip of the internal condyle to the radial side of the pisiform.

The posture of the limb, also, is of moment. In indicating the exact situation of the femoral or brachial arteries, for instance, it is essential that the limb should be placed in a certain position before the line is drawn.

The size of the artery should be realised. In the sections which follow, the dimensions—as given by Quain—are noted in connection with each vessel.

The operator should also be aware of the possible variations of the artery to be exposed.

2. *The Incision.*—The incision should—when possible—be so placed upon the line of the artery as to avoid superficial veins. It is most desirable that there should be little bleeding during the operation, that the wound should be "dry," and the view of the depths not embarrassed by pressure forceps.

The scalpel should be held in what is termed the dinner-knife position. (*See* Fig. 13, page 51.) The cut should be freely made and cleanly cut. There is a disposition to make the wound too small. A small wound carries with it special dangers and difficulties, whereas a little increase in the length of the skin-cut does not add to the gravity of the procedure. It is frequently adduced as a demonstration of skill, that such and such an artery has been ligatured through an incision of unusually small dimensions. These exhibitions of dexterity

are only suited for the deadhouse. While the incision should not be one line longer than is possible, it should be long enough to enable the artery to be reached and exposed with ease and safety. The experimenter on the cadaver, who ties the common carotid through an inch incision, not improbably includes the vagus nerve in his ligature.

The knife should be entered at right angles to the surface, and should be in the same position when withdrawn. The surface wound should be of equal depth throughout. There should be no "tails" to the cut.

The skin should be steadied with the left hand while the integuments are being divided.

After the surface cut has been made, the next step is to divide the deep fascia, or aponeurosis. This is done by a clean cut made in the line of the original incision, and carried the whole length of the wound.

A director is not required either at this or any other stage of the operation. In the ligature of arteries the director should be avoided as an unnecessary and dangerous weapon. (*See* page 53.)

When the deep fascia has been exposed in a limb, the outlines of the underlying muscles and tendons are rendered more or less distinct. A gap between two adjacent muscles has usually to be followed in the operation. This gap is very commonly said to be indicated by a white or a yellow line. The "yellow line" is due to the fat occupying the hollow between the muscles, and is not seen in wasted subjects; nor is it clear in the cadaver, nor in a limb which has been deprived of blood by Esmarch's band.

The "white line" is almost equally deceptive; it depends upon a thickening of the fascia itself, due to the attachment of an inter-muscular septum. In ligaturing the ulnar artery in the forearm, the operator is instructed to seek for "the white tendinous margin of the flexor carpi ulnaris." That white margin has no real existence, nor is a "white line" in the fascia by any means constant in this position. (*See* the section on the ligature of this artery.) In cutting down upon the upper third of the anterior tibial artery also, the "white line" which is supposed to guide the surgeon to that vessel has a very uncertain existence, as is pointed out in the account

of that operation. Not infrequently the gap between the muscles is indicated by an inter-muscular artery.

The interval is best sought by the sense of touch and by the left index finger. A highly-educated left index finger is the most valuable factor in the performance of any operation for the ligation of an artery.

The space is to be felt when it cannot be seen, and the artery itself is often more surely to be recognised by the finger than by the eye. Farabeuf well says:—"C'est donc les yeux en l'air et le doigt dans la plaie qu'il s'habituera à lier certaines artères, une fois les incisions superficielles accomplies." It is especially when the parts are uniformly obscured by blood that the value of a practised forefinger is appreciated.

The muscular interspace is best opened with the handle of the scalpel or with the finger. No attempt should be made to demonstrate it by the edge of the scalpel. Dissection is here out of place. The narrow and obscure tract of connective tissue that leads down to the artery is better followed by the sensitive finger than by any sharp instrument. And here again Farabeuf advises well:—"Mais il aurait tort de ne pas se servir du doigt, du *seul index gauche,* délicatement utilisé, non de *tous* les doigts des deux mains, comme le font certains maladroits dont le faire devient ainsi malpropre, brutal et grossier. Sans le toucher, la ligature d'une artère devient le plus souvent une vaste dissection; ce n'est plus une opération à traumatisme limité."

In opening up the depth of the wound the posture of the limb may be so altered as to relax the muscles about the incision. It is better that this should not be done until the interspace has been well and clearly demonstrated.

The deep part of the wound should follow the line of the superficial incision, and should equal it in extent. The wound should not be funnel-shaped.

Retractors must be freely used. Every means must be adopted to expose the depths of the wound clearly. All bleeding must be checked as it is encountered. Small pieces of the finest Turkey sponge should be employed to sponge the wound and to keep it dry to its very bottom. In effecting this end the part can often be so inclined that blood tends to flow from the wound by gravitation rather than into it.

Above all things, the operation must be conducted step by step. Each guiding point must be well made out before the next point is sought for. This circumstance is well illustrated by the operation for securing the lingual artery.

3. *The Exposure of the Artery.*—The artery should be sought for with the finger. As the tissues will be more or less evenly stained with blood, the finger—in a deep wound especially—affords the best means of differentiating the artery, the veins, and a companion nerve.

To the touch the nerves feel firm, resisting, round, and cord-like. They cannot be flattened by the pressure of the finger. The veins greatly exceed the corresponding arteries in size. They often overlap these vessels. They feel soft and yielding, and thin-walled. They are easily compressed, and when so treated swell out upon the distal side. When the finger touches the compressed vein the vessel as a tube can scarcely be appreciated. In this respect it is very different from the artery. The artery feels firmer and more elastic. It is not unlike a thin indiarubber tube to the touch. It is movable, and often slips about under the finger in a characteristic manner. It can be compressed, but not so readily as the vein. When flattened out by the finger, an artery of moderate dimensions feels like a flat band or thong, thick and elastic, and hollowed out a little in the centre, so that the margins feel thicker than the median part. Above all, it pulsates.

There are many fallacies in this. The pulsations of the artery may be transmitted to the nerve (as in the case of the median nerve and the brachial), or to the companion vein. When the patient is under an anæsthetic, and when the pulse is feeble, or very rapid, the movement in the artery may be difficult to detect. If an aneurysm or pulsating growth exist, compression of the artery causes the pulsation in the tumour to cease.

The artery when exposed is often found much contracted. It looks so much smaller than was expected, that it may, in such case, be mistaken for an abnormal vessel.

In the matter of the appearance of the tissues, the depth of the wound—which is often great—and the even tinting of the parts with blood, render an inspection of less value than

an examination with the finger. When the wound is well opened up the nerves stand out as clear, rounded, white cords; the veins are of a purple colour, and of somewhat uneven and wavy contour; the artery is regular in outline, and is of a pale pink or pinkish-yellow tint, the large vessels being of lighter colour than the small.

There may be one companion vein or two—the *venæ comites.* All arteries below the knee are accompanied by venæ comites. All arteries of the arm, forearm, and hand are attended in like manner.

The arteries of the trunk, which are of small or of medium size, are for the most part accompanied by venæ comites; such are the pudic, the deep epigastric, the deep circumflex iliac, and the internal mammary.

The arteries in the head and neck are attended by single veins, the only noteworthy exception to this being the lingual artery.

The venæ comites lie close to the artery, one upon each side of it. They are apt to communicate with one another freely across the vessel by means of many transverse branches. When the artery is placed between muscles which lie the one in front of the other—as is the case with the posterior tibial artery—the companion veins lie one on each side of the single trunk. When, however, the muscular interspace is antero-posterior, as is the gap between the tibialis anticus and the extensor communis digitorum, in which the anterior tibial artery lies, the veins are placed so that one is in front of the artery and the other behind it.

4. *The Opening of the Sheath.*—The artery is now reached. It remains to open the sheath, and to clear a part of the vessel for the passage of the aneurysm needle.

The sheath must be opened with the scalpel with infinite care and the most delicate precision. The knife must have a perfect cutting edge. A good light is essential, and a pair of trustworthy forceps by means of which it is possible to pick up a fine fold of tissue, and hold it firmly.

The sheath is picked up over the *centre*, or median part, of the artery, in the form of a fold which is *transverse* to the long axis of the vessel. It must be picked up cleanly and entirely. It is unwise to pick up a longitudinal fold. In the

first place, such a fold is not so easily grasped nor so readily raised from the vessel, and, in the second place, the forceps may catch up at the same time a longitudinal fold of the subjacent arterial coat, or even of one of the veins.

The transverse fold of the sheath is then incised. The cut should be clean, should be made in the *long axis* of the artery, and over the *centre* of the vessel. In length it should be from 5 to 10 m.m.

When the sheath has been well divided, the serous-like space between it and the artery becomes at once evident.

Before the incision is made, the point of the forceps may be moved a little to and fro, to ensure the freedom of the part which is held from any deep attachments. The sheath may in this way be really identified.

The blade of the scalpel should be inclined obliquely, *i.e.*, with the flat of the knife towards the artery.

The fold of the sheath must be held well up during the making of the incision. When once a good hold of the sheath has been obtained by the forceps the instrument must not be shifted.

In this part of the operation a director is not only useless but dangerous. The opening of the sheath with a blunt instrument is a proceeding which does not belong to the surgery of the present age.

The method of picking up the sheath with two pairs of forceps (one of which is held by an assistant), and then of cutting between the two blades, is cumbrous, inconvenient, and not without danger.

5. *The Passing of the Ligature.*—The original hold of the forceps upon the sheath should not be relaxed. The surgeon now takes the aneurysm needle in his right hand, and introduces its unthreaded point between the artery and the sheath for the purpose of clearing the former. The needle should be held with its concavity towards the vessel, and it should be gently insinuated about half-way round the artery, being passed under that part of the sheath held up by the forceps.

The sheath upon the opposite side of the incision should now be taken up with the forceps, and the needle be passed beneath the vessel so as to clear the remaining portion—the deep part—of its surface. The needle will soon emerge in the

wound upon the opposite side of the artery, when it should be threaded, and be then withdrawn, carrying the ligature with it.

About one centimètre of the artery more or less is cleared. The needle should be kept throughout at right angles to the line of the vessel. It should never be passed threaded.

It is the usual practice to pass the needle from the vein. A more important rule is to pass the needle from the forceps.

It is often more convenient to pass it towards the vein. If the sheath has been well opened, and a way for the ligature carefully cleared around the artery, there can be little excuse for forcing the point of the needle through the sheath into the companion vessel.

If a *large vein be wounded*, the practice advised by Mr. Jacobson ("The Operations of Surgery," page 986) in the case of wound of the femoral vein during the ligaturing of the artery should be carried out. "The surgeon must not persist in his attempt to tie the artery at the spot, a course which will only end in his inflicting more injury on the vein; but finger-pressure being made on the lower angle of the wound, the artery is tied either above or below the spot where the vein has been injured. As soon as the artery is secured no further hæmorrhage will take place, but pressure may be kept up by means of a carbolised sponge over the wound for a day or two." A small puncture in a large vein may usually be safely closed by picking up the wounded part of the wall and passing a fine catgut ligature around it, as one would tie up a hole in a bag.

When venæ comites attend a deep artery of moderate size, such as the ulnar or posterior tibial, much time may be wasted and damage done by a determined attempt to separate the artery from the veins. This is especially the case when many transverse connecting branches pass across the artery. In such instances practice has shown that no evil results from including the two veins in the ligature. In dealing with still smaller arteries, such as the lingual, no attempt is made to avoid including the companion veins in the ligature.

It is needless to say that the greatest care must be taken to avoid including a nerve in the ligature. If the sheath be well opened, and the needle be kept close to the artery and

be passed round with ease, there is little danger of including a nerve.

The catgut passed around the artery should have been rendered pliable by a short immersion in a weak carbolic solution.

The ligature should be passed and be tied exactly at right angles to the line of the artery. The knot should be tied quietly and slowly, and not with a vicious jerk.

It should be sufficiently tight to rupture the inner coats. Care should be taken that the vessel is not dragged out of place in the tying.

The points of the two forefingers should meet upon the artery as the knot is being tied, and the final strain upon the ligature should be given by placing the terminal knuckles of these two fingers in contact and using them as the fulcrum of a lever.

Messrs. Ballance and Edmunds have shown (*Med.-Chir. Trans.*, Vol. lxix.) that it is not strictly necessary for success in obliterating arteries to divide the inner coats. Mr. Holmes, however, after an elaborate criticism of this point in the paper already alluded to, considers that it is safer and better to tie the artery tightly.

Fig. 24.—The Figure to the right shows a reef knot, that to the left a "granny."

The *knot* should be a reef-knot (Fig. 24), not a "granny." The double-hitch, or surgical knot, is not suitable, more especially when catgut is employed. With this material it may be found to be impossible or very difficult to tighten the knot about the artery. Moreover, the knot when made with catgut forms a considerable mass, and is, at the best, a clumsy method of occluding the vessel.

The reef-knot, if well tied, will not fail.

The practice of applying a *double ligature* to the artery, and of dividing the vessel between them, has been revived from time to time since Celsus advised it. Abernethy re-introduced the practice in 1797, and was strongly in favour of it, as also were Sédillot, Mannoir, Cline, and others. Secondary hæmorrhage was observed to be much less common

after amputation than it was after the application of a ligature for aneurysm, and it was believed that, by applying a double ligature and dividing the vessel between, this tendency would be lessened. The question is thus reviewed by MacCormac:—"The artery is able to retract somewhat on each side after division, the tension is lessened, and its condition in consequence resembles that of a vessel tied on the face of a stump. The artery, too, under these circumstances, may be tied nearer to its undisturbed connections, a practice which it may be well to adopt in cases where an unhealthy wound already exists, and where the patient's general condition is such as to render primary union of the wound improbable.

"The safety and greater facility of employing, as a rule, only a single ligature, are, however, amply demonstrated by experience, and the advantages of the other method are not so considerable as to lead to its general adoption. In cases where the artery lies deeply, where the external wound is comparatively small, and where surrounding structures are important and space limited—as, for instance, near to the iliac arteries, the innominate, or the subclavian artery—it may be quite impossible to isolate the vessel sufficiently to apply two ligatures and divide the artery between them. It will also be more difficult to discover the end of the divided artery if secondary hæmorrhage ensue. The presence of a lateral branch may likewise occasion serious embarrassment, or render double ligature impracticable." Mr. Holmes considers that Abernethy's proposal is "a step backwards."

The After-Treatment.—The superficial wound is closed by sutures, and dressed in the usual way. No drainage-tube is required.

In the case of the main artery of one of the extremities, the limb should be kept absolutely at rest, and be a little raised. The arm would lie outstretched upon a pillow, the lower limb would be raised upon an inclined plane. The whole extremity is enveloped in cotton wool, and is kept warm by hot bottles. In the case of the ligature of vessels of the size of the iliacs, the subclavian, or the common femoral, absolute rest should be enforced for a period of not less than twenty-one days.

The time involved in the after-treatment of cases in which

smaller vessels have been ligatured may be regulated in proportion. The period of compulsory rest should be longer in old subjects than in the young, and in cases in which the lower limb is concerned than in the upper.

In the chapters which follow, the operation for the ligature of the chief arteries which come within the field of surgery is described.

No attempt, however, has been made to give an account of every operation of this kind which might possibly be carried out. The operations upon the smaller arteries are performed to arrest or to prevent hæmorrhage; the circumstances of such operations are simple, are influenced mainly by the condition of the wound or injury, and need no detailed description. Almost every minor artery in the body has been at one time or another secured, but the simple anatomical conditions, and the common surgical principles involved in these procedures, would not justify a systematic description in each instance.

The average dimensions of each of the larger arteries, such as the subclavian and the iliacs, are given in the account of the anatomy of the vessel. The calibre of arteries of or below the size of the common carotid is expressed by a Roman figure after the name of the vessel (*e.g.*, Posterior Tibial, iii.). This refers to one of the six orders into which Henle divided these vessels according to their average calibre.

These orders are as follows, and are thus arranged in Quain's "Anatomy":—

Order.	Average Calibre.	Example.
I.	8 m.m. ($\frac{1}{3}$ inch).	Common carotid.
II.	6 m.m. ($\frac{1}{4}$ inch).	Brachial.
III.	5 m.m. ($\frac{1}{5}$ inch).	Ulnar.
IV.	3·5 m.m. ($\frac{1}{7}$ inch).	Lingual.
V.	2 m.m. ($\frac{1}{12}$ inch).	Posterior Auricular.
VI.	1 to ·5 m.m. ($\frac{1}{25}$ to $\frac{1}{50}$ inch).	Supra-orbital.

CHAPTER II.

Ligature of the Arteries of the Upper Limb.

THE RADIAL ARTERY (IV.).

Anatomy.—The radial artery continues the line of the brachial, and although it is smaller than the ulnar, must be regarded morphologically as the main artery of the forearm.

The relations of that part of the vessel only which lies in the forearm will here be considered. (For the anatomy of the artery in the "tabatière anatomique," *see* page 117.)

The radial follows a nearly straight course from the bifurcation of the brachial artery—opposite the neck of the radius—to the inner side of the styloid process of that bone.

The upper half of the artery is covered by the muscular mass of the supinator longus, the lower half by the skin and fascia only. The supinator longus muscle becomes tendinous about the middle of the forearm.

The vessel has behind it, in order from above downwards, the biceps tendon, supinator brevis, insertion of pronator teres, radial origin of flexor sublimis, flexor longus pollicis, pronator quadratus, and the lower end of the radius.

Venæ comites—connected by many transverse branches—accompany the artery, one lying upon each side of the vessel.

The radial nerve is only in direct relation with the artery in the middle third of the forearm. It here lies to its outer side. In the upper third of the limb the nerve is at a considerable distance from the artery, while some three inches above the wrist it leaves the vessel altogether to pass beneath the supinator longus tendon to the back of the hand.

Line of the Artery.—A line from the centre of the bend of the elbow, to the gap between the scaphoid bone and the tendons of the extensor ossis and extensor primi internodii pollicis.

Indications.—The arteries of the forearm—radial and ulnar—are not frequently ligatured; the circumstances which usually call for ligature are wound and traumatic aneurysm.

Position.—The surgeon stands upon the side to be operated on. The limb is in the position of supination, and is firmly held by an assistant, who grasps it by the hand and by the upper arm. The incision on the right side should be made from above downwards; on the left side it is conveniently made in the opposite direction.

1. **Ligature in the Lower Third of the Forearm.**

Operation.—An incision about one inch and a quarter in length is made over the line of the pulse, midway between, and parallel with, the tendons of the supinator longus and flexor carpi radialis muscles. The cut must not reach below the level of the tuberosity of the scaphoid (Fig. 25).

Fig. 25.—LIGATURE OF THE RADIAL AND ULNAR ARTERIES, AND OF THE BRACHIAL AT THE BEND OF THE ELBOW.

The commencement of the superficial radial vein usually lies over the artery in this situation, and immediately under the skin. It should be avoided.

The fascia, which is here quite thin, is divided in the line of the original wound. The gap between the two tendons is now made manifest. Over, or in close relation to, the artery may be observed the terminal part of the anterior division of the external cutaneous nerve.

It may be impossible to separate the venæ comites from the artery to a sufficient extent to allow the needle to pass. In such case the ligature must include the veins as well as the artery (Fig. 26).

Comment.—The operation is extremely easy. Some confusion may arise in cases where the superficialis volæ artery has a high

origin, and lies upon, or by the side of, the radial. This is especially the case when the branch is of unusual size.

Fig. 26.—LIGATURE OF THE RIGHT RADIAL AT THE WRIST.
A, Fascia; a, Artery.

It is said that the synovial sheath of the flexor carpi radialis tendon has been accidentally opened in this operation.

2. **Ligature in the Middle Third of the Forearm.**

Operation.—An incision two inches in length is made in the line of the artery, the limb being in the position indicated. The centre of the incision corresponds to the centre of the forearm (Fig. 25). In cutting through the subcutaneous tissues care must be taken to avoid any superficial vein belonging to the radial or median veins.

The anterior division of the musculo-cutaneous nerve lies usually in the line of the artery, outside the deep fascia and just beneath the superficial veins.

The deep fascia is laid bare and is divided in the length of the original wound. The fibres are transverse (Fig. 27).

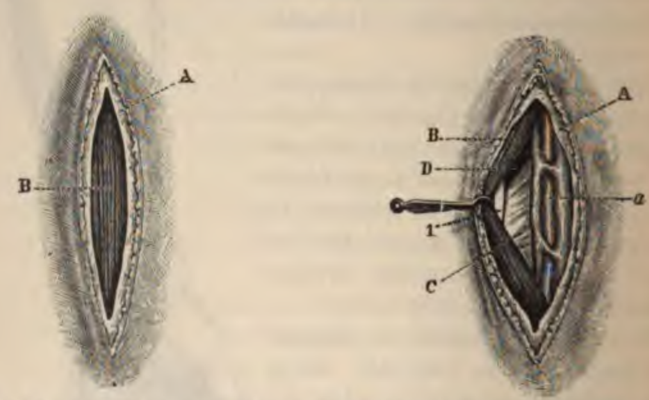

Fig. 27.—LIGATURE OF THE RIGHT RADIAL, ABOUT THE MIDDLE THIRD OF THE FOREARM.

Superficial Wound.—A, Fascia; B, Sup. long.

Deep Wound.—A, Fascia; B, Sup. long.; C, Insertion of pron. teres; D, Sup. brevis; a, Artery; 1, Radial nerve.

The supinator longus muscle is now exposed about the point where it is beginning to become tendinous. The inner

or ulnar border of the muscle is defined and the muscle itself is drawn outwards. The elbow may be a little flexed to allow of this being done more easily.

The vessel is now found lying upon the insertion of the pronator radii teres, with which it is connected by much connective tissue. The nerve may or may not be seen (Fig. 27).

The venæ comites should be separated as well as is possible and the needle passed from whichever side is the more convenient.

Comment.—As the supinator longus is not very wide at this part (especially if the artery be sought for at the lower end of the middle third) it is very easy to expose the outer instead of the inner border of the muscle, in which case the muscle is apt to be drawn inwards, and when the depths of the wound are opened up the radial nerve is reached. This is the common error of beginners.

The tendon of the supinator longus as a rule first makes its appearance at the outer border of the muscle, so that if this tendinous edge be exposed the operator will know that he has laid bare the wrong side of the muscle. The inner border of the supinator remains muscular, until it ends somewhat abruptly in the tendon.

3. Ligature in the Upper Third of the Forearm.

Operation.—This operation differs very little from the last. The incision is two and a half inches in length, and is made in the line of the artery. The centre of the skin-cut corresponds to the part of the vessel to be tied. The radial or other surface vein may be encountered in the superficial part of the wound. After the deep fascia has been divided, the interval between the supinator longus and pronator teres muscles is opened up. There is no difficulty in identifying these two structures; the fibres of the supinator are vertical; those of the pronator are oblique. In muscular subjects the supinator is so wide that its inner border cannot be readily exposed.

Under cover of the supinator the radial artery will be found. The nerve is not in relation with it. The needle should be passed from whichever side is the more convenient.

4. Ligature of the Radial in the Tabatière Anatomique.—*Anatomy.*—The tabatière anatomique is a triangular space bounded on one side by the extensor ossis metacarpi pollicis

and extensor primi internodii, and on the other side by the extensor secundi internodii pollicis. The base is represented by the lower edge of the posterior annular ligament. In the floor of the space are the trapezium, with a part of the scaphoid and of the base of the first metacarpal bone.

The radial artery runs over the external lateral ligament of the wrist, just below the styloid process, passes under the extensors of the metacarpal bone and first phalanx of the thumb, and crosses the tabatière. Its course is here represented by a line drawn from the apex of the styloid process of the radius to the posterior angle of the first interosseous space.

The cephalic vein of the thumb crosses the space posteriorly, as does also the internal division of the terminal branch of the radial nerve. A branch of the anterior division of the external cutaneous nerve accompanies the artery which gives off, while in the upper part of the space, the posterior carpal and first interosseous branches.

Operation.—This procedure belongs rather to that series of dissecting-room operations which are of value as demonstrating anatomical knowledge.

The hand is placed upon its ulnar border, and is firmly fixed there by an assistant, who at the same time holds the thumb extended and abducted and the fingers straight.

An incision, about one inch in length, is made along the centre of the tabatière, parallel to the extensor of the metacarpal bone of the thumb, and so placed as to commence at the level of the radial styloid process and lie midway between the extensor ossis and the extensor of the second phalanx of the thumb. The incision will cross the artery a little obliquely. The cephalic vein of the thumb must be avoided. The artery is ligatured in the middle of its course. It will probably be impossible to separate the venæ comites.

It is said that in performing this operation carelessly the synovial sheaths of the adjacent tendons have been opened up, or the joint between the scaphoid and the trapezium has been exposed.

For the variations in the radial artery, *see* page 123.

THE ULNAR ARTERY (III.).

Anatomy.—This, the largest artery of the forearm, follows

a curved course in the upper third of the limb. It is perfectly straight in direction in the lower two-thirds.

In the first half of its course in the forearm it is deeply placed beneath the superficial flexors, viz., the pronator radii teres, flexor carpi radialis, palmaris longus, and flexor sublimis. From about the middle of the forearm to a point within one inch of the wrist, the vessel is overlapped by the flexor carpi ulnaris. For the last inch of its course in the forearm it is superficial, and is covered only by the integuments and the fascia.

The vessel lies at first upon the insertion of the brachialis anticus, and then for the rest of its course in the forearm upon the flexor profundus.

Venæ comites, united by many cross branches, accompany the vessel.

The ulnar nerve comes in contact with the artery at a point a little above the middle of the forearm. Throughout the lower half of the forearm the two are close together, the nerve lying to the inner side of the artery.

Line of the Artery.—The ulnar in the lower two-thirds of its course in the forearm is represented by a line drawn from the tip of the internal condyle of the humerus to the radial side of the pisiform bone.

The curve of the vessel in the upper third of its course is such that a line drawn from the commencement of the artery —at the middle of the bend of the elbow—to the radial side of the pisiform bone, will scarcely touch the vessel in any part of its course.

The upper third of the artery is too deeply placed to be exposed for ligature, unless it be actually laid bare in a wound.

Indications.—These have been already alluded to (page 115). The artery is secured only in the lower two-thirds of the limb.

Position.—As for ligature of the radial artery in the forearm.

1. Ligature in the Lower Third of the Forearm.

Operation.—An incision, two inches in length, is made along the line of the artery, just to the radial side of the flexor carpi ulnaris tendon. The incision terminates an inch or less

above the pisiform bone (Fig. 25). Care must be taken to avoid any tributary to the superficial ulnar vein which may be over the line of the artery. The deep fascia—which is here very slender—is exposed and divided.

The tendon of the flexor carpi ulnaris muscle is now displayed. The wrist is a little flexed to relax the tendon, which is gently drawn inwards by a blunt hook. The vessels are now exposed. The artery in this situation is bound down to the flexor profundus by a definite layer of fascia. This must be carefully divided. The nerve is close to the artery, and upon its inner side (Fig. 28). It may be impossible to isolate the artery from the companion veins. The needle is passed from within outwards. The palmar cutaneous branch of the ulnar nerve lies upon the artery in this situation, and must be avoided.

Fig. 28.—LIGATURE OF THE RIGHT ULNAR AT THE WRIST.

A, Fascia; B, Edge of flex. carp. uln. tendon; a, Artery; 1, Ulnar nerve.

Comment.—It is possible that the operator may expose the inner side of the flexor carpi ulnaris tendon by mistake. On this (the wrong) side of the tendon, muscular fibres will be found entering the tendon almost down to the wrist. On the radial side the tendon is quite clear. Care must be taken not to wound the synovial sac, which accompanies the flexor sublimis digitorum tendons beneath the annular ligament. Normally the ulnar gives off no branch in this situation. The posterior carpal arises a little above the pisiform bone.

2. Ligature in the Middle Third of the Forearm.

Operation.—An incision, from two and a half to three inches in length, according to the muscular condition of the limb, is made precisely in the line of the artery (Fig. 25). Beneath the integuments the anterior ulnar vein and branches of the anterior division of the internal cutaneous nerve are apt to be encountered. The deep fascia is thin, and is divided in a line parallel with, but a little to the outer side of the line of, the skin incision.

The surgeon now seeks for the gap between the flexor carpi ulnaris muscle and the flexor sublimis digitorum (Fig.

29). The position of this interval is sometimes indicated by a white line. (See *Comment* upon the operation.) The gap is, however, best demonstrated by the touch, the left forefinger being used for the purpose. As soon as the intermuscular space has been made evident, the wrist is a little flexed to relax the muscles. The flexor carpi ulnaris is now drawn inwards by means of a broad-bladed retractor. The flexor sublimis is in like manner drawn a little outwards. The surgeon opens up the vertical intermuscular space thus demonstrated, and at the bottom of it will probably first be found the ulnar nerve. To the outer side of the nerve is the artery (Fig. 30). The fascia binding down the vessels in this situation is slender. There is usually no difficulty in separating the artery from its venæ comites.

Fig. 29. — LIGATURE OF THE RIGHT ULNAR AT THE MIDDLE THIRD OF THE FOREARM.

Superficial Wound.—A, Fascia; B, Palmaris longus; C, Flex. carp. ulnaris; *b*, Superficial vein.

The needle should be passed from within outwards so as to avoid the nerve.

Comment.—This operation is associated with considerable difficulty if carelessly performed, and the procedure is surrounded by many possibilities of error.

Fig. 30.—LIGATURE OF RIGHT ULNAR AT THE MIDDLE THIRD OF THE FOREARM.

Deep Wound.—A, Fascia; B, Flex. sublimis; C, Flex. carp. ulnaris; D, Flex. profundus; *a*, Artery; 1, Ulnar nerve.

The chief difficulty is to demonstrate the gap between the flexor carpi ulnaris and flexor sublimis muscles.

The "white line" which is said to mark this gap is not to be relied upon. There may be no trace of such a line: it may be very faintly indicated, or the position of the interspace may be marked by a yellow fatty line. The white line is best seen in young muscular subjects. In the aged and wasted it is usually absent. In corpulent subjects the linear deposit of fat is commonly present.

The white line, when it does exist, indicates the tendinous margin of the flexor carpi ulnaris. This tendinous tissue belongs to the tendon of origin of the muscle, and not to that of the insertion, as usually stated. At the level of the centre of the forearm there is seldom any trace of the tendon of insertion. A faint variety of the white line is sometimes produced by an unusual intermuscular septum. The flexor carpi ulnaris is much more closely adherent to this septum than is the flexor sublimis, and when the fascia is divided the septum adheres to the former muscle, thus producing a species of fascial margin.

The interspace between the two muscles in question is not quite straight, *i.e.*, is not quite vertical when the limb is in position for the operation. The flexor carpi ulnaris overlaps the flexor sublimis a little, and the line of the interspace is directed as is shown at *a* in Fig. 31. The fibres of both the muscles follow the long axis of the limb.

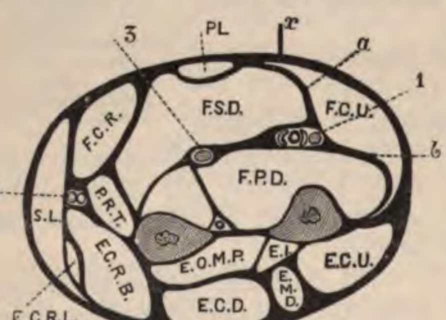

Fig. 31.—TRANSVERSE SECTION OF THE FOREARM (DIAGRAMMATIC), TO SHOW THE INTERMUSCULAR SPACES ABOUT THE MIDDLE THIRD.

nitials indicate the tendons and muscles. *a*, Ulnar artery interspace; *b*, Interspace to be avoided; *x*, the surgical line of the ulnar artery; 1, Ulnar vessels; 2, Radial vessels; 3, Median nerve.

If the division of the deep fascia be exactly in the line of the skin incision, *i.e.*, in the line of the artery *x*, the knife will probably cut upon the flexor carpi ulnaris.

By dividing the fascia a little more to the outer side as advised, the knife comes upon the flexor sublimis (*see* Fig. 31), and by working inwards the oblique gap between the muscles is made out. This gap is always best demonstrated by the finger. It is often indicated by one or more cutaneous arteries which escape here and form an excellent guide to the main artery. The interspace should be sought for at the lower part of the wound, and the separation of the two muscles should take place from below upwards.

It may be noted that the flexor sublimis at the middle third of the forearm presents a few fine commencing tendon fibres.

In muscular subjects care should be taken that the incision is made long enough.

It is only by the display of great carelessness that it would be possible to open up the interspace between the flexor sublimis and palmaris longus muscles.

When the proper interval has been found between the flexor sublimis and the flexor carpi ulnaris, it is not uncommon for the beginner—impressed with erroneous views as to the depths of the artery—to proceed too deeply and too far to the inner side, and to actually pass by the ulnar nerve and open up the interspace between the flexor carpi ulnaris and the flexor profundus digitorum. (*See b*, Fig. 31.)

This may readily happen if the former muscle be dragged too much to the inner side.

Collateral Circulation after Ligature of the Radial or Ulnar Artery.—After ligature of one of these vessels, the collateral circulation is very readily and freely established, through the cross anastomoses between the arteries in question, through the palmar and carpal arches and through the interosseous vessels.

Varieties of the Radial and Ulnar Arteries.

1. The radial has been found outside the fascia, and subcutaneous.
2. The ulnar may be subcutaneous or subfascial in its entire course.
3. The median artery may be of large size and be largely concerned in the supply of the palm.
4. The radial artery may be absent.

THE BRACHIAL ARTERY (II.).

Anatomy.—The brachial artery commences at the lower margin of the teres major, and bifurcates at a point on a level with the neck of the radius. It lies in the depression along the inner borders of the coraco-brachialis and biceps muscles.

In the upper two-thirds of its course it lies on the inner aspect of the shaft of the humerus, and can be compressed

against the bone by pressure in a direction outwards and slightly backwards. In its lower third the humerus is behind it, and compression, to be effectual, should be directed backwards. It runs between the skin and deep fascia as far as the elbow, where it dips into the interval between the supinator longus and pronator teres muscles, and passes beneath the bicipital fascia. In muscular subjects the artery may be overlapped to a considerable extent by the edge of the biceps.

It lies, in order from above downwards, upon the long head of the triceps (the musculo-spiral nerve and superior profunda artery intervening), the inner head of the triceps, the insertion of the coraco-brachialis (at the middle of the arm), and the brachialis anticus. It is fixed to the latter muscle by its sheath. It is accompanied by venæ comites, one on each side, which are connected with one another by many transverse branches. The inner of these veins is much the larger. The basilic vein lies to the inner side of the artery, but is separated from that vessel, in the lower part of the limb, by the fascia. It pierces the fascia about the middle of the arm. It may then attend the artery to the axilla, or may join at once with the inner of the two venæ comites.

The median nerve crosses in front of the artery about or below its middle, lying to the outer side of the vessel above that point, and to its inner side below.

The ulnar nerve is to the inner side of the artery as far as the insertion of the coraco-brachialis; it then leaves the vessel to run to the gap between the internal condyle and the olecranon.

The internal cutaneous nerve lies in front or to the inner side of the artery, in about the upper half of its course. The nerve pierces the fascia, and becomes subcutaneous about the middle of the arm.

The inferior profunda artery is represented by a line drawn from the inner side of the humerus at its middle to the back part of the internal condyle. The nutrient artery enters the bone at its inner aspect opposite the deltoid insertion, and the anastomotic vessel comes off about two inches above the bend of the elbow.

At the bend of the elbow the biceps tendon can be well

felt, its outer edge being more evident than the inner. The crease in the skin called the "fold of the elbow" is placed some little way above the line of the articulation. At the spot where the biceps tendon ceases to be distinctly felt, and at the outer side of that tendon, the median, median basilic, median cephalic and deep median veins join. The median basilic vein passes in front of the biceps tendon, the brachial artery, and the median nerve. The median basilic vein may cross the artery abruptly and be comparatively free of it except at the point of crossing, or it may run for some distance quite in front of the artery, or crossing it early, it may lie parallel with the vessel, although at a different level for the greater part of its course.

Line of the Artery.—When the arm is extended and abducted with the hand supine, the brachial artery corresponds to a line drawn from the outlet of the axilla (at the junction of its middle and anterior thirds) to the middle of the bend of the elbow.

Indications.—The artery is rarely ligatured at the bend of the elbow except for wounds and for traumatic arterio-venous aneurysm. In the arm it is often secured for wound, for hæmorrhage from the palmar arches and from the elbow and forearm, and for traumatic aneurysm. Spontaneous aneurysm is very rare in the brachial artery. Dr. Holt (*Amer. Journ. Med. Sciences*, April, 1882) only succeeded in collecting thirteen cases of such aneurysm.

Position.—In securing the artery at the bend of the elbow, the limb, extended and abducted, may be allowed to rest upon the olecranon. It should not be over-extended.

In dealing with the vessel in the arm, the limb should be extended and abducted, with the hand supine, and should be held away from the body. The arm itself should not be supported in any way, but the limb should be held by the forearm by an assistant.

The surgeon may make the incision from above downwards on both sides of the body, standing to the outer side of the limb on the right side, and between the trunk and the limb on the left side. Or on the left side the operator may place himself to the outer side of the limb, and, bending over it, may make the incision from below upwards.

1. Ligature at the Bend of the Elbow.

Operation.—The arm having been placed in the position indicated, the surgeon, by flexing and extending the limb, makes out the exact position of the biceps tendon, and by compressing the veins of the upper arm, renders evident the median basilic vein.

An incision, two inches in length, is made through the skin, along the inner edge of the biceps, and parallel with its margin. The wound will therefore be oblique, and it should be so placed that its centre corresponds to the mark on the skin called the "fold of the elbow" (Fig. 25). The upper end of the incision will correspond to the level of the tip of the internal condyle. If the veins be normally disposed, the skin wound will lie to the outer side of the median basilic vein, and nearly parallel to it.

As soon as the vein is exposed, it should be drawn inwards. The bicipital fascia is now demonstrated, and divided in the line of the original incision. Its fibres are directed obliquely downwards and inwards. The artery, with its venæ comites, will now be exposed. The vessel will here be found to be very movable and free from connective tissue attachments, although sometimes surrounded by much fat (Fig. 32).

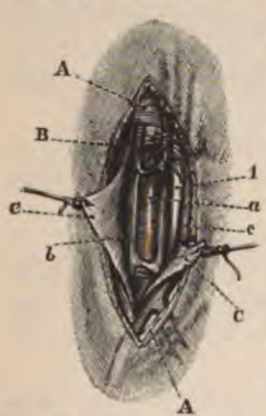

Fig. 32.—LIGATURE OF THE RIGHT BRACHIAL AT THE BEND OF THE ELBOW.

A, Fascia; B, Biceps tendon; C, Bicipital fascia; a, Artery; b, Venæ comites; c, Basilic vein; 1, Median nerve.

The venæ comites having been separated, the needle is passed from within outwards. The median nerve does not come conspicuously into the field of the operation. It is nearest to the artery (on its inner side) at the upper part of the wound.

Comment.—Care should be taken that the operation is performed so as to ensure primary healing. Suppuration following this procedure has led to a stiff elbow. The median basilic vein is closely attached to the thin integument, and, unless made quite evident, may easily be wounded.

2. Ligature at the Middle of the Arm.

Operation.—The limb having been

placed in the position indicated, an incision about two and a half inches in length is made along the inner edge of the biceps muscle, in the line of the artery (Fig. 34).

The fascia, which is here thin, is exposed and divided, and the muscular layer is reached. It is extremely important that the inner margin of the biceps be clearly exposed and surely identified. The muscle is displaced a little outwards, and the pulsation of the vessel is sought for. A little dissection exposes the median nerve—if it be not already in view (Fig. 33). In the middle of the arm the nerve usually lies in front of the artery. In applying a ligature to any part of the brachial, at or above the middle of its course, the nerve should be drawn outwards. If the brachial be exposed below the middle section, the nerve is more conveniently displaced inwards.

While the artery is being exposed the elbow may be flexed for a moment.

The sheath of the artery having been opened, and the venæ comites separated as well as possible, the needle is passed from the nerve. The inner of the two companion veins is usually much the larger.

Fig. 33.—LIGATURE OF THE RIGHT BRACHIAL AT THE MIDDLE OF THE ARM.

A, Fascia; B, Biceps; C, Triceps; *a*, Artery; *b*, Vena comes; 1, Median nerve; 2, Internal cutaneous nerve.

In the upper part of its course the inner margin of the coraco-brachialis muscle is exposed in the place of the biceps, and the ulnar nerve is lying to the inner side of the vessel.

Comment.—This artery is by no means so easy to ligature as may appear; and in an operative surgery class no more glaring mistakes are made than occur in the course of searching for this superficial vessel.

In the first place, the arm should be unsupported, and be at right angles to the trunk. If the arm be allowed to rest upon a table, the triceps may be pushed forwards, and may be then mistaken for the biceps; while the ulnar nerve has been mistaken for the median. This observation especially applies to the middle third of the limb.

The vessel is mobile, and is easily displaced, and in drawing the biceps aside roughly with a retractor, the vessels and the median nerve have been withdrawn from the field of the operation, and possibly the ulnar nerve brought into view. The clear identification of the biceps margin is essential. The advice sometimes given, that the "sheath of the muscle" should not be opened, is neither sound nor very precise.

The pulse in the brachial is often much feebler than would be imagined; and this is especially the case in dealing with severe hæmorrhage. The pulsation may be so clearly transmitted to the median that that nerve has been mistaken for the artery.

It is asserted that the basilic vein has been mistaken for the artery. Tillaux states that a large inferior profunda artery has been taken for the brachial.

If the incision be made too much to the inner side of the proper line, the basilic vein may be wounded, especially when it is superficial, *i.e.*, in the lower segment of the arm.

In very muscular subjects the biceps may overlap the artery considerably. The frequent abnormalities of the brachial must in all instances be borne in mind.

Collateral Circulation after Ligature of the Brachial Artery.

1. If above the origin of the superior profunda.

Above.		*Below.*
Posterior circumflex	with	Ascending branches of superior profunda.

2. If below the origin of the inferior profunda.

Above.		*Below.*
Superior profunda	with	Anastomotic. Radial recurrent. Posterior interosseous recurrent.
Inferior profunda	with	Anastomotic. Posterior ulnar recurrent. Posterior interosseous recurrent.

Varieties of the Brachial Artery.

1. The artery may run towards the inner condyle, and pass beneath a supra-condyloid process.
2. The artery may show a high division. The branch prematurely separated will be, in order of frequency,

the radial, the ulnar, the interosseous, or a vas aberrans.

The site of the high division is most usually in the upper third of the arm, less often in the lower third, and rarest in the middle third.

The two vessels usually run side by side, the abnormal artery being the more superficial.

3. The median nerve may pass behind the brachial artery.
4. The vessel may be crossed by a muscular slip derived from the pectoralis major, biceps, coraco-brachialis, or brachialis anticus.

THE AXILLARY ARTERY.

Anatomy.—The axillary artery extends from the lower edge of the first rib to the lower margin of the teres major muscle.

Its position is much influenced by the position of the arm. The vessel is conveniently divided into the three parts—the segment above the pectoralis minor, the segment beneath the muscle, and the segment beyond the muscle. The first part measures about one inch in length, the second one inch and a quarter, and the third part about three inches.

The *first part* of the artery is deeply placed, is covered in by the pectoralis major and costo-coracoid membrane, and is invested by a fairly substantial sheath. It is overshadowed by the clavicle and the subclavius muscle. It rests upon the first intercostal space, the second rib, the second and third serrations of the serratus magnus muscle, and the nerve of Bell. Crossing over the front of the vessel from without inwards are the cephalic vein, the acromio-thoracic vein, and the external anterior thoracic nerve.

The cords of the brachial plexus lie to the outer side of the vessel.

The axillary vein is of large size, is influenced, as to its dimensions, by respiratory movements, is superficial to the artery, and is placed on its inner side. When the arm lies by the side the vein is actually to the inner side of the artery: but when the limb is held at right angles to the body the vein is drawn across the artery, and, in the living subject, conceals it.

The vein is somewhat closely attached to the costo-coracoid membrane.

The acromio-thoracic and superior thoracic arteries are given off from this part of the vessel. The upper border of the pectoralis minor is represented by a line drawn from the third rib, near its cartilage, to the coracoid process. The lower border of the muscle follows a line drawn from a corresponding part of the fifth rib to the same process.

The *second part* of the artery requires no notice.

The *third part* is covered by the pectoralis major at first, and then only by the integuments and fascia. It rests upon the sub-scapularis and the tendons of the latissimus dorsi and teres major. The circumflex and musculo-spiral nerves pass behind it. The coraco-brachialis muscle lies to its outer side, and the axillary vein to its inner side. This vein is formed by the junction of the two venæ comites. This junction is usually not effected until the lower border of the subscapularis muscle is reached Thus two veins are commonly found in relation with the lowest part of the artery, and if the basilic vein has not yet joined the inner vena comes, three veins may be met with. The subclavian vein, in the form of a single trunk, may not have an existence until the region of the clavicle is reached.

The ulnar nerve lies to the inner side of the artery, between it and the vein. The nerve of Wrisberg is placed to the inner side of the vein. The internal cutaneous nerve and the inner head of the median are in front of the artery, while the trunk of the median and the musculo-cutaneous lie to the outer side.

The internal cutaneous and the median are the nerves most closely connected with the artery.

The subscapular, posterior and anterior circumflex arteries come off from the third part.

Line of the Artery.—A line from about the centre of the clavicle to the humerus, close to the inner border of the coraco-brachialis, will represent the artery when the arm is so abducted as to be at right angles to the body.

Indications.—The ligature of the axillary artery is practically limited to its third part. The artery has been tied for wound, for hæmorrhage from the limb below, for axillary

and brachial aneurysm, and for the treatment of subclavian aneurysm, by the distal operation.

The axillary appears to have been first tied by R. Chamberlaine, of Jamaica, for traumatic aneurysm of the axilla in 1815 (*Med.-Chir. Trans.*, vol. vi., page 128). The first part of the vessel was secured, and the operation was successful. Dr

Fig. 34.—LIGATURE OF THE BRACHIAL ABOUT THE MIDDLE OF THE ARM, AND OF THE THIRD PART OF THE AXILLARY.

Holt (*Amer. Journ. Med. Sciences*, 1882) reports a ligature of the first segment of the artery for the relief of hæmorrhage attending a ligature of the third part. The patient did well. In exceedingly few instances, however, has the first segment of the vessel been secured; and in very few have the results been encouraging.

The conditions requiring the obliteration of the first part of the artery must be so remarkably uncommon that the operation can scarcely rank as a regular surgical procedure. When a high ligature is required, it should be applied to the third part of the subclavian.

The dangers and difficulties attending a high ligature of the axillary are so considerable as to render the procedure questionable. The wound is deep, the vein is closely connected with the costo-coracoid membrane, is very prominent and large, and apt to be torn. The danger from the entrance of air into a vein is not inconsiderable, and the operation involves the opening up of a deep and extensive area of connective tissue.

1. **Ligature of the Third Part.**

Operation.—The patient is placed upon the back, close to

the edge of the table, and has the shoulders raised. The arm is at right angles to the body, and is held horizontally.

The surgeon may place himself between the arm and the thorax when about to secure either artery. It is the practice of some to stand to the outer side of the limb, near the patient's head, and to bend over the extremity, when operating upon the right axillary. The axilla should be shaved.

An incision, about three inches in length, is made along the line of the artery. It commences at the middle of the outlet of the axilla, at the junction of its anterior and middle thirds, and is continued down along the inner margin of the coraco-brachialis muscle (Fig. 34). The knife should be held with the blade horizontal. After the integuments and fascia have been divided, the inner margin of the coraco-brachialis should be thoroughly exposed. This muscle, with the musculo-cutaneous nerve, is then drawn gently outwards. The position of the artery may now be determined with the finger. In exposing it the median nerve is at once made evident, and should be drawn outwards by means of a small blunt hook. The internal cutaneous nerve should be gently displaced inwards. The venæ comites need to be well demonstrated. The artery having been cleared, the needle is passed from within outwards (Fig. 35).

Fig. 35.—LIGATURE OF THE RIGHT AXILLARY ARTERY (3RD PART).
A, Fascia; B, Coraco-brachialis; a, Artery; b, Venæ comites; 1, Median nerve; 2, Int. cutaneous nerve.

Comment.—The numerous nerves in relation with this part of the vessel somewhat confuse the operation. The veins are apt to obscure the vessel. There may be three veins in relation to this part of the axillary—the two venæ comites and the still free basilic. Abnormalities in the artery must be anticipated. A muscular slip passing from the latissimus dorsi to join the pectoralis major, biceps, or coraco-brachialis, may cross over the vessels. Such a slip may

readily be mistaken, when large, for the coraco-brachialis muscle.

The ligature should not be applied too near any one of the branches of the artery.

2. **Ligature of the First Part.**

Operation.—The patient lies upon the back, close to the margin of the table, with the upper part of the body raised. The point of the shoulder should be carried well back, and to effect this a hard cushion may be placed between the scapulæ. The arm is allowed to lie by the patient's side. It must not be dragged upon so as to depress the point of the shoulder.

The operator should stand upon the outer side of the limb, near the patient's trunk, when dealing with the left side, and near the head when dealing with the right. A good reflected light is necessary.

A slightly curved incision, with the convexity downwards, is made across the supra-clavicular fossa. The cut commences just outside the sterno-clavicular joint, and ends just outside the coracoid process. It passes about half an inch below the clavicle, and the centre of the incision is about opposite to the centre of that bone (Fig. 36).

The skin, platysma, supra-clavicular nerves, and fascia are divided in the first incision. At the outer end of the wound care must be taken not to wound the cephalic vein and the large branch of the acromio-thoracic artery.

The cephalic vein should be exposed, and forms a useful guide to the artery.

The pectoralis major is divided through its entire thickness close to the clavicle, and to the full extent of the original wound. The upper edge of the lesser pectoral should be defined and drawn down.

The costo-coracoid membrane must now be dealt with. It should not be torn through, but should be divided vertically near to the coracoid process. The cephalic vein, if well brought out, will indicate the position of the axillary vein. The latter vessel is readily torn in freeing a way through the costo-coracoid membrane.

The artery is now exposed, and the needle should be passed from the vein. The vein should be held aside with the finger while the needle is being passed.

It must be remembered that the vein is least in the way when the arm is by the side.

Comment.—There is great danger of tearing the axillary vein, and also of air being drawn into some of the smaller veins. If the pectoralis minor receive a slip from the second rib, the area of the operation is much curtailed. The cord or the brachial plexus nearest to the artery may be mistaken for that vessel.

The operation described may be considered as a modification of Chamberlaine's original proceeding.

Delpech made an oblique incision downwards along the gap which separates the pectoralis major from the deltoid, the wound starting from the clavicle. The two muscles were then separated from one another, the pectoralis minor divided near to the coracoid process, and the vessel drawn outwards and secured. The operation is needlessly difficult.

Guthrie was an advocate for what must certainly be called a free incision. His incision was "made in the course of the axillary artery, through the integuments, superficial fascia, and the great pectoral muscle—in fact, through the anterior fold of the armpit." The extent of the wound was only limited by the position of the proposed ligature.

Collateral Circulation after Ligature of the Axillary Artery.

1. If the first part be ligatured above the origin of the acromio-thoracic, the collateral circulation will be the same as after ligature of the third part of the subclavian.
2. If the third part be secured below the circumflex vessels, the condition is the same as after ligature of the brachial above the superior profunda.
3. Ligature of the third part between the origins of the subscapular and the two circumflex.

Above.		*Below.*
Suprascapular Acromio-thoracic	with	Posterior circumflex.

4. Ligature of the third part above the origin of the subscapular. The same anastomoses as just given, with

Above.		*Below.*
Long Thoracic Intercostals Posterior Scapular Suprascapular	with	Subscapular.

Varieties of the Axillary Artery.

1. In one case out of every ten (R. Quain) the axillary gives off a large branch, which will be most frequently the radial, sometimes the ulnar, less frequently a vas aberrans, and very rarely the interosseous artery.
2. A trunk may arise from the third part of the artery from which will spring the subscapular, the two circumflex and the two profunda arteries.

CHAPTER III.

Ligature of the Arteries of the Head and Neck.

THE SUBCLAVIAN ARTERY.

Anatomy.—The subclavian artery, starting from the aorta on the left side and the innominate on the right, arches across the lower part of the neck to reach the axilla. In the neck it usually reaches to the height of a point on a level with the sixth cervical vertebra. The length of the right artery is about three inches, the left about four. The latter vessel is a little smaller than the right. The diameter of the subclavian diminishes from 11 m.m. to 9 m.m.

The first part of the artery is considered to extend from the origin of the vessel to the inner edge of the anterior scalene muscle. The second part is that which lies behind the anterior scalene muscle, and the third part is that beyond the muscle.

The right subclavian and the cervical part of the left commence opposite the upper part of the sterno-clavicular joint. The *first part* of the artery is deeply placed beneath the integuments, the platysma, the sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles, and the cervical fascia. It is near to the trachea, is in contact with the pleura below and behind, and is in close relation with the innominate, internal jugular and vertebral veins, the vagus, recurrent laryngeal, cardiac and sympathetic nerves. The left subclavian is also in relation with the thoracic duct and the phrenic nerve. From this part of the artery arise the vertebral, the internal mammary, and the thyroid axis.

The *second part* of the artery reaches highest in the neck, and lies between the anterior and middle scalene muscles.

It is still in relation with the pleura, and is separated from the phrenic nerve by the anterior of the two muscles.

The superior intercostal artery arises from this part.

The *third part* of the subclavian represents the segment of the vessel which crosses the posterior triangle of the neck, and which is nearest to the surface. It is the part to which the ligature is applied. It runs in a triangle, the base of which is formed by the outer edge of the anterior scalene and the sides by the clavicle and omo-hyoid. The omo-hyoid is generally found about one inch above the clavicle in this situation. It may, however, be found almost level with the bone, or so high up as not to be encountered in the operation. Much depends upon the position of the shoulder.

The third part of the artery is covered by the integuments and platysma, by the cervical fascia and a fibrous expansion which stretches from the omo-hyoid to the clavicle. It rests upon the first rib, the middle scalene muscle is behind it, the cords of the brachial plexus are above it.

The last cord, derived from the eighth cervical and the first dorsal, is nearest to the artery. The little nerve to the subclavian muscle crosses in front of the vessel, and nearer to the surface the supra-clavicular nerves descend in front of the subclavian triangle.

The subclavian vein lies below the artery and anterior to it. It passes in front of the scalenus anticus (Fig. 37).

The external jugular vein is placed in front of the artery, although its relations to the vessel vary considerably. It receives in this region the transverse cervical and suprascapular veins, which may form a plexus over the subclavian artery.

The suprascapular artery lies behind and under cover of the clavicle. The transverse cervical artery crosses beneath the omo-hyoid muscle at some distance above the main vessel. No branch arises normally from this part of the subclavian.

Indications.—A ligature has been applied to each of the three parts of the subclavian artery. So far as surgical experience at present extends, it may be said that the operation is only justifiable when the third part of the artery is concerned.

A ligature has been applied to this portion of the vessel in cases of axillary aneurysm, in cases of wound, and in instances of hæmorrhage from the axilla. It has been applied also as a distal ligature in the treatment of innominate and aortic

aneurysms, and as a preliminary step in excision of the scapula, in the removal of large axillary growths, and in amputation of the entire upper limb. The operation on the whole may be considered to be satisfactory, although the risks of secondary hæmorrhage and of intra-thoracic inflammation are considerable. These risks have been greatly reduced since wounds have been treated antiseptically. The mortality after ligature of the third part for axillary aneurysm is notably high, death following frequently from suppuration of the sac and secondary hæmorrhage. Norris showed that in sixty examples of this operation the mortality was forty-five per cent.

Ligature of the third part of the artery was first attempted by Sir Astley Cooper in the spring of 1809. He was unable to complete the operation. In the autumn of the same year Ramsden ligatured the artery for the first time (*Practical Observations: London*, 1811). The patient died. During succeeding years several surgeons carried out Ramsden's operation, but all the patients died. The first successful case was treated by Post, of New York, who operated in September, 1817 (*Med.-Chir. Trans.*, vol. ix., page 185). The first success in Great Britain was obtained by Liston in 1820 (*Edin. Med. and Surg. Journ.*, vol. xvi., page 348).

The first part of the subclavian was first ligatured by Colles, in 1818. Ashhurst has collected nineteen examples of this operation, but not a single patient survived. In one case, that by Mr. Mitchell Banks, the patient survived the ligature thirty-six days. In this instance the innominate had already been tied (Jacobson's "Operations of Surgery," page 537).

The operation, so far as present experience goes, may be said to be distinctly unjustifiable. No artery could be less favourably placed for the application of a ligature. It is deeply situated, is near the heart, is in contact with the pleura, is surrounded by immense veins, and is in intimate relation with such nerves as the vagus, the phrenic, the recurrent laryngeal, and the cardiac. Moreover the ligature is applied about a part of the vessel where numerous large branches are arising.

The method adopted has been similar to that carried out in exposing the innominate artery.

The second part of the vessel was ligatured by Dupuytren.

He has had a few imitators, but no patient subjected to this operation has survived.

Position.—(To ligature the third part.)—The patient lies upon the back close to the edge of the table, with the thorax raised and the head extended and turned to the opposite side.

The arm should be pulled well down and fixed. This latter object is best effected by passing the arm behind the back whenever that is possible, and allowing it to remain fixed in that posture. The operator stands in front of the shoulder. A good light is necessary.

Ligature of the Third Part of the Subclavian Artery.

Operation.—The skin over the posterior triangle having been drawn down with the fingers of the left hand, an incision is made through it down to the clavicle. By adopting this plan a risk of wounding the external jugular vein is avoided.

Fig. 36.—LIGATURE OF THE FIRST PART OF THE AXILLARY ARTERY, THE THIRD PART OF THE SUBCLAVIAN, THE COMMON CAROTID, AND THE LINGUAL.

The incision, which is transverse, should be about three inches in length, and when the traction upon the skin is withdrawn should lie about half an inch above the clavicle (Fig. 36). It should extend across the base of the posterior triangle from the trapezius to the sterno-mastoid, and should be so planned that the centre of the wound shall correspond to a point about one inch to the inner side of the centre of the clavicle. This first incision divides the integuments, the platysma and the supraclavicular nerves, with possibly a vein which passes over the clavicle to connect the cephalic vein with the external jugular. The amount of trapezius and sterno-mastoid exposed will

depend upon the extent to which those muscles are attached to the clavicle.

The deep cervical fascia is now reached, and is divided in the length of the original wound. No director should be employed. If the surgeon cannot divide the fascia without the aid of this dangerous instrument he had better not attempt the operation. The external jugular vein must now be dealt with. Very probably it can be drawn aside and may be held by a small blunt hook towards the outer angle of the wound. If it obstruct the area of the operation in a more determined manner, it may have to be divided between two ligatures. Sometimes when an actual plexus of veins exists in front of the artery much difficulty is encountered. All bleeding vessels must be secured. The wound throughout should be as bloodless as possible.

The outer margin of the anterior scalene muscle should next be defined, and the position of the omo-hyoid made out. The latter muscle, if at all in the way, must be drawn upwards. When the edge of the scalene muscle has been made plainly evident, the finger should be passed along it until the tubercle on the first rib is encountered. The finger will now be in contact with the artery, and its pulsations can be felt (Fig. 37).

The vessel will be found actually resting upon the bone. A little careful dissection will clear the artery and bring into view the lowest cord of the brachial plexus.

This nerve cord should be systematically exposed by a slight and careful dissection. It may be at once said that it has been the source of some of the more serious mistakes which may be made in this operation. The subclavian vein will be seen and felt, but it seldom encroaches much upon the field of the operation.

The transverse cervical artery runs high up, and will probably not come into view. The suprascapular artery keeps under cover of the clavicle. The fascia surrounding the subclavian is fairly substantial.

The needle (unthreaded) may now be very carefully passed from above downwards and from behind forwards. Its course must be directed by the forefinger of the left hand. By this finger the vein is protected and held out of the way. If the needle be passed from below—*i.e.*, from the vein—it is easy to

pick up the last cord of the plexus with the artery. The pleura has been wounded by a needle which has been carelessly passed.

Comment.—The incision above described is substantially the same as that carried out by Ramsden.

The operation is difficult, and requires a very steady hand and a very perfect control over the scalpel and forceps. The parts should be cautiously exposed by means of the knife, and

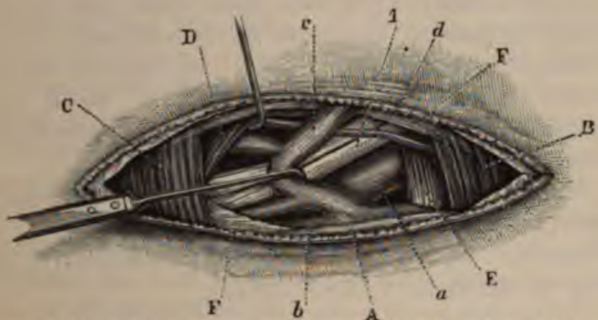

Fig. 37.—LIGATURE OF THE RIGHT SUBCLAVIAN (THIRD PART).
A, Clavicle; B, Sterno-mastoid; C, Trapezius; D, Omo-hyoid; E, Anterior scalene; F, Cervical fascia; *a*, Subclavian artery; *b*, Subclavian vein; *c*, Ext. jugular vein; *d*, Transverse cervical artery; 1, Brachial plexus.

not by means of tearing and rending with the fingers and blunt instruments.

One author advises that no further use should be made of the knife when once the deep fascia has been divided. The rest of the operation may be accomplished, he affirms, by tearing. This procedure is uncouth, unsurgical, and barbarous. It encourages the rending of the many veins in the vicinity, the displacement of the tissues, and the rupture of the pleura. With reference to this plan of operating by tearing, however, the author in question consoles the reader by the observation that "herein lies the difference in my teaching from that of other operators."

In order to obtain sufficient room, portions of the trapezius or of the sterno-mastoid may have to be cut.

The transverse cervical or suprascapular arteries may be in the way. They should be drawn aside, but in no case divided,

as they play a most important part in the collateral circulation. These arteries have been injured during the operation, as have also been the external jugular vein and the phrenic nerve.

If the neck be short and the patient stout, the difficulties of the operation are much increased. Great difficulty will also be experienced when the veins have a plexiform arrangement or are engorged, and when the tissues are found to be œdematous and matted together.

The pleura has been several times wounded in passing the needle, and in many of the fatal cases where this accident is not noted the patient succumbed to intra-thoracic inflammation. Both Liston and Green passed the ligature around the last cord of the brachial plexus by accident. South has seen the posterior scapular artery picked up and mistaken for the subclavian.

In very few instances does the subclavian vein appear to have been wounded.

Difficulties may be caused by the presence of a cervical rib or by an abnormality in the artery.

Collateral Circulation after Ligature of the Third Part of the Subclavian Artery.

Above.		*Below.*
Suprascapular Posterior scapular	with	Acromio-thoracic and Subscapular.
Internal Mammary Aortic Intercostals Superior Intercostals	with	Thoracic and Scapular branches of Axillary.

Varieties of the Subclavian Artery:—

1. Variations in the origin of the subclavian have little effect upon the third part of the artery.
2. A cervical rib may exist, and the artery be carried upon it, or upon the fibrous cord in which such ribs often terminate anteriorly.
3. The artery may reach as high as one inch or even (especially on the right side) one inch and a half above the clavicle, or may be so low as to be entirely under cover of the clavicle.
4. The artery may perforate the anterior scalene muscle, and in rarer cases may be in front of it.

5. The posterior scapular artery, and more rarely the suprascapular, may arise from the third part of the artery.

THE INNOMINATE ARTERY.

Anatomy.—This vessel has a diameter of about 14 m.m., a length of from one to two inches, and is roughly represented by a line drawn from the centre of the manubrium to the sterno-clavicular joint. "The place of bifurcation would, in most cases, be reached by a probe passed backwards through the interval between the sternal and clavicular portions of the sterno-mastoid muscle" (Quain). The artery may divide at a point considerably below the clavicle, and, less frequently, at a point above it. The vessel may in some uncommon instances give off the thyroidea ima, or even the internal mammary or bronchial arteries.

The innominate is separated from the sternum by the sterno-hyoid and sterno-thyroid muscles, the remains of the thymus gland, and, near its root, by the left innominate vein.

It is in close connection with the trachea, and in still more intimate relation with the pleura. On the right side are the right innominate vein and the vagus nerve; on the left are the inferior thyroid veins and the left carotid artery.

Indications.—This vessel has been secured for the relief of carotid and subclavian aneurysms. The results, however, of the operation have been such that it is questioned whether it is to be considered as a justifiable surgical procedure.

So far as present experience extends as to the circumstances which influence the success of the ligature of large arteries, it would appear that ligature of the innominate carries with it a better prospect of success—other things being equal—than does ligature of the first part of the subclavian. It is true that the innominate is deeply and inconveniently placed; it is true that the operation is exceedingly difficult; it is true that the vessel is nearer to the heart; but, on the other hand, the trunk gives off normally no branches, there is room for the application of the ligature, and the vessel is not in so intimate relation with such nerves as the vagus, the sympathetic, the phrenic, and the recurrent laryngeal, as is the first part of the subclavian.

It would appear (Ashhurst) that this ligature has been carried out at least twenty-four times: but only two patients have survived the operation. One of these cases was under the care of Dr. Smyth, of New Orleans (*Syd. Soc. Bien. Retros.*, 1865-6, page 346). The patient, after exhibiting symptoms of secondary hæmorrhage, recovered and lived ten years. In the second case the operation was performed by Mr. Mitchell Banks (Jacobson's "Operations of Surgery," page 529), and the patient lived fifteen weeks.

In all the fatal cases death has followed from secondary hæmorrhage. Some patients have survived the operation many days. Thus Thompson's patient lived forty-two days, and Graefe's sixty-seven days. Both ultimately succumbed to secondary hæmorrhage.

Several of the operations included in the list have been performed within quite recent times, and under the most approved antiseptic principles, but the results have not been substantially modified.

The great danger is from secondary hæmorrhage, which takes place apparently always from the vessel on the distal side of the ligature. Other complications have appeared, such as suppurative cellulitis, pericarditis, cerebral embolism, lung troubles, &c.

The first operation was performed by Dr. Mott, of New York, in 1818, for subclavian aneurysm. The patient died on the 26th day of secondary hæmorrhage (*Med. and Surg. Register of New York*, 1818, page 8). An excellent summary of the chief cases is given by Mr. W. G. Spencer in a paper published in *The British Medical Journal*, July 13th, 1889.

Operation.—The position of the patient and of the surgeon is the same as in the previous operation. A good light is required, and means should be at hand for illuminating the depths of the wound. Several aneurysm needles of different patterns, and presenting several varieties of curve, should be provided.

The operation here described is identical in all essential particulars with the original procedure of Mott.

An incision is made along the upper border of the inner third of the clavicle, and a second cut follows the anterior edge of the sterno-mastoid muscle. Each incision is at least

three inches in length, and they join one another at an acute angle.

The skin and superficial structures having been divided, the flap marked out is dissected up.

The sterno-hyoid and sterno-thyroid muscles are now divided close to the sternum, together with so much of the sterno-mastoid as is exposed in the wound.

Care must be taken of the anterior jugular vein, which passes behind the last-named muscle near its origin. The vein is inconstant in size, and should be divided between two ligatures. The deep cervical fascia is exposed and divided in the lines of the superficial wound. The operator now seeks for the common carotid artery, and having opened the sheath of that vessel as low down as possible, he follows it until he is led to the bifurcation of the innominate.

"It is now," writes Mr. Jacobson, "that the real difficulties will be met with. (1.) Owing to engorgement of the venous circulation, increased by the anæsthetic, the internal jugular and innominate vein may be so much enlarged as to protrude through the wound. (2.) An aneurysm may have reached under the artery and flattened it out so as to make it difficult of recognition. The cellular tissue around the vessel and between it and the sternum may be so matted with adhesions as to make it difficult to define the artery and its important relations on the right side—viz., vagus, pleura, and right innominate vein. (3.) The artery itself may be enormously diseased and expanded. In tracing down the innominate itself, the surgeon must keep his steel director most carefully on the front of the artery. In following the vessel down behind the sternum in order to find a site for his ligature, he will be aided by slightly flexing the head and by a laryngeal mirror. The cleaning the artery must be done with the utmost caution, especially on the outer side, owing to the important structures lying there; of these the innominate vein and the vagus may be drawn outside, but it is only by keeping the director or needle-point very close to the artery here that injury to the pleura can be avoided."

The needle should be passed from without in, and a little from below upwards, so as to avoid the pleura as far as possible.

In order to avoid the chief danger of the operation—secondary hæmorrhage from the distal side of the ligature—the common carotid and the vertebral should be ligatured at the same time. The procedure involves, therefore, the securing of three arteries.

No drainage-tube should be used, and every possible means should be taken to bring about a primary healing of the wound.

Comment.—Much has been said upon the subject of the best ligature to use in this operation. In the two successful cases silk and tendon were respectively employed. So far as it is possible to form an opinion, the precise nature of the ligature would appear to be a matter of no very great importance. No substantial objection has been urged against well-prepared, carefully selected, chromicised catgut. The tendon ligature has much to recommend it.

Flat ligatures can hardly be said to have established undoubted claims of superiority. The flat ligature is clumsy, and is not readily passed around the artery. The knot formed is very bulky. If tightly applied, the whole of the ligature does not lie flat upon the artery, but near the knot it will be usually found to be cutting into the vessel with its edge. It can only be said of these ligatures that they are flat before application. It has not been shown that they are free from the objection of becoming loosened on account of the knot becoming soft or untied.

In Mr. May's case of ligature of the innominate, the flat ligature passed around the vessel snapped in the tying, and this very serious accident was repeated twice. He substituted for the flat ligature a cord made of five or six medium-sized threads of catgut. The knot was very large, and he thinks that the pressure of it upon the vessel was the cause of the secondary hæmorrhage of which the patient died. Mr. Holmes is disposed to regard the flat ligature favourably.

In Mr. Thompson's case of ligature of the innominate, the patient lived six weeks. An ox-aorta ligature was used. The vessel was found to be obliterated, and the ligature had entirely disappeared.

Collateral Circulation after Ligature of the Innominate Artery (as given by MacCormac).

	Cardiac side.		*Distal side.*
Trunk.	First aortic intercostal	with	Superior intercostal of subclavian.
	Upper aortic intercostals	with	Thoracic branches of axillary, and intercostals of internal mammary.
	Phrenic	with	Musculo-phrenic of internal mammary.
	Deep epigastric	with	Superior epigastric of internal mammary.
Head.	Free communication of vertebrals and internal carotids of opposite sides inside the skull. Communication of branches of opposite external carotids in middle line of the face and neck.		

THE VERTEBRAL ARTERY (III.).

Anatomy.—The vertebral artery is the size of the ulnar, and arises about one-third of an inch to the inner side of the anterior scalene muscle from the upper and back part of the first part of the subclavian artery.

The vessel passes upwards, and a little backwards and outwards, and enters the foramen in the transverse process of the sixth cervical vertebra. It runs in the gap between the anterior scalene muscle and the longus colli. The internal jugular vein and the vertebral vein lie in front of it. The inferior thyroid artery crosses it anteriorly, as does also the thoracic duct upon the left side (Fig. 38).

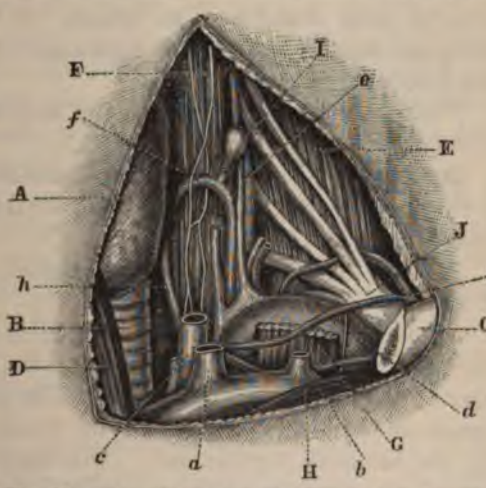

Fig. 38.—ANATOMY OF THE VERTEBRAL AND INFERIOR THYROID ARTERIES. (*Modified from Godlee's Atlas.*)

A, Thyroid glard; B, Trachea; C, Clavicle; D, Sterno-thyroid; E, Scalenus medius; F, Longus colli, with sympathetic nerve upon it; G, Scalenus anticus (cut); H, Subclavius; I, Transverse process of 6th cervical vertebra; J, Brachial plexus; *a*, Left innominate vein receiving internal jugular; *b*, Ext. jugular vein entering subclavian vein; *c*, Common carotid artery, with vagus nerve to its inner side; *d*, Subclavian artery crossed by nerve to subclavius *e*, Vertebral artery and vein; *f*, Inferior thyroid artery.

The vessel lies upon the transverse process of the seventh cervical vertebra, and the cord of the sympathetic descends behind it. The vertebral is accompanied by a plexus from the inferior cervical ganglion.

The accessible part of the artery measures about one inch and a quarter.

Indications.—The vertebral has been ligatured in cases of injury, and also in a few instances of traumatic aneurysm.

It has been ligatured—with other arteries—in the treatment of aortic and innominate aneurysms by the distal method, and has been secured as a precaution after ligature of the innominate. At one time ligature of this vessel was practised as a means of treating epilepsy; the operation was, however, soon abandoned as useless. It was carried out in thirty-six cases of epilepsy by Alexander, of Liverpool; out of this number three patients died.

The vessel was first ligatured by Smyth, of New Orleans, in 1864.

Operation.—The position of the patient and of the surgeon is the same as in the operation upon the third part of the subclavian (page 139).

A good light is needed on account of the great depth of the wound.

An incision, three inches in length, is commenced at the clavicle, and is carried upwards along the outer or posterior edge of the sterno-mastoid muscle. The skin and superficial tissues are divided, and especial care is taken to avoid wounding the external jugular vein. The deep fascia having been severed, the sterno-mastoid is exposed, and with the jugular vein is drawn inwards.

It will probably be necessary to divide some part of the clavicular attachment of the sterno-mastoid close to the bone. The operator now defines the scalenus anticus, and makes evident the interval between that muscle and the longus colli. With the finger he should make out the position of the common carotid artery and internal jugular vein, and define the transverse processes of the seventh and sixth cervical vertebræ. The process of the latter vertebra forms a good guide, and below it the pulse of the artery should be

felt. The various structures encountered must be carefully displaced to one or other side.

The vertebral vein lies in front of the artery, and should be pushed aside. Care must be taken not to damage the inferior thyroid vessels, the pleura, or, on the left side, the thoracic duct. The phrenic nerve need not be exposed. The needle is passed from without inwards.

With regard to certain pupil phenomena attending the operation, Sir W. MacCormac thus writes: "Immediate contraction of the corresponding pupil, due to interference with the dilating fibres of the cervical sympathetic, is of very constant occurrence, and may be regarded as a pretty certain indication that the vessel has been secured. Two small nerves from the inferior cervical ganglion, at first a little separated from the artery, are afterwards very closely applied to it. When these are included in the loop of the ligature, the contraction of the pupil will continue for a considerable time. A temporary contraction will occur when the nerves are excluded, because of the almost unavoidable irritation to which they are subjected during the steps of the operation."

Comment.—The ligature of this artery is a matter of no little difficulty. The greatest care must be taken to avoid injury to the various important structures which lie adjacent to the vessel. Both the inferior thyroid and the ascending cervical arteries have been mistaken for the vertebral.

THE INFERIOR THYROID ARTERY (IV.).

Anatomy.—This vessel arises from the thyroid axis at the inner margin of the anterior scalene muscle. It passes upwards in front of the vertebral artery and longus colli muscles, and then bending inwards and a little downwards, passes behind the common carotid, the internal jugular vein, the vagus, and the sympathetic (Fig. 38). The middle cervical ganglion rests upon it. The ascending cervical branch arises from the vessel just as it is about to pass behind the carotid. The ligature is applied to the artery on the distal side of this branch.

The recurrent laryngeal nerve is in close relation to the artery at its termination, and is nearly parallel to it at its

commencement. The thoracic duct passes in front of the root of the left artery.

The inferior thyroid may arise direct from the subclavian, or have origin from the common carotid or vertebral. It may be double, or entirely absent.

The size, course, and situation of the vessel vary very greatly in cases of bronchocele.

Indications.—The vessel is secured as a preliminary measure in removing the thyroid body, and in cases of injury. It has been ligatured also, together with the superior thyroid, for the purpose of arresting the growth, or of diminishing the size, of a bronchocele. The very free anastomoses between the thyroid vessels, and the dangers of the procedure, have rendered this measure very unsatisfactory. (*See* article by Wölfler, *Wien. Med. Woch.*, 1886, and summary of thirty-one cases.)

Operation.—An incision, three inches in length, is made along the inner edge of the lower part of the sterno-mastoid muscle, just as in ligature of the common carotid low down. The wound reaches to the clavicle. The sterno-mastoid is exposed and drawn outwards, the carotid artery and its vein are reached and are drawn carefully *outwards*. The surgeon now seeks for the transverse process of the sixth cervical vertebra, and a little below that the artery may be discovered, passing inwards from behind the carotid (Fig. 38). It is ligatured close to the carotid, and in this way the immediate neighbourhood of the recurrent laryngeal nerve is avoided.

THE COMMON CAROTID ARTERY (I.).

Anatomy.—The right common carotid commences at the level of the sterno-clavicular articulation, and the cervical part of the left may be considered to commence at the same point. The vessel bifurcates opposite to the upper margin of the thyroid cartilage, on a level with the third cervical vertebra. The omo-hyoid crosses the carotid opposite to the lower margin of the cricoid cartilage, on a level with the sixth cervical vertebra.

The vessel *below the omo-hyoid* is deeply placed, being covered in front by the skin, platysma, fascia, sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles. This part of the

artery may also be overlapped by the thyroid body. The anterior jugular vein passes in front of it, and the inferior thyroid artery and recurrent laryngeal nerve behind it.

The vessel *above the omo-hyoid* is superficial, being covered only by the skin, platysma, and cervical fascia, and overlapped by the inner margin of the sterno-mastoid muscle. This part of the artery is crossed by the sterno-mastoid branch of the superior thyroid artery, and by the superior thyroid vein. The middle thyroid vein will usually cross the carotid with the omo-hyoid muscle. The superior thyroid vein is often double, and may, in some cases, form a species of plexus in front of the carotid.

Along the inner border of the sterno-mastoid, below the hyoid bone, a vein generally runs which serves to connect the facial vein with the anterior jugular.

Behind the common carotid, in its entire course, are the cervical vertebræ, the longus colli muscle, and the sympathetic nerve. Above the level of the cricoid cartilage, the rectus capitis anticus major muscle is also posterior to the artery.

The carotid sheath is derived from the cervical fascia, and is very substantial. It encloses the artery, the internal jugular vein, and the vagus nerve. Each of the three has its own especial investment. The nerve is posterior to both the artery and the vein, and its canal lies in the septum which separates these two vessels. The vein is to the outer side of the artery—on the right side the two become a little separated at the root of the neck, while on the left side the vein overlaps the artery slightly in that position. The right jugular vein is larger than the left, and the combined sectional areas of the two jugular veins are to those of the carotids as twenty to eleven. The descendens noni nerve descends along the front of the carotid sheath, inclining gradually from the outer to the inner side. The nerve frequently runs within the sheath. The sympathetic nerve is close to the carotid sheath behind.

Line of the Artery.—The course of the common carotid is represented by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the tip of the mastoid process.

A valuable guide to the artery, at about the point of crossing of the omo-hyoid muscle, is afforded by Chassaignac's

"carotid tubercle." This is the costal process of the sixth cervical vertebra, and the artery lies directly over it. It is to be found about two and a half inches above the clavicle.

Indications.—The common carotid has been tied for many different conditions. It has been ligatured on account of wound, on account of hæmorrhage arising from definite branches of the external carotid (*e.g.*, the superior thyroid, lingual, temporal), and on account of bleeding generally from parts on the distal side of the vessel. Thus the carotid has been secured in cases of hæmorrhage from the orbit, the middle ear, the tongue, the mouth, the tonsil, the maxillæ, and in cases of cut throat, gunshot wound, and the like.

A ligature has been applied in cases of aneurysm of the external or internal carotid, in intracranial aneurysm, and in examples of angeiomata involving the branches of the carotid. The distal ligature has been applied to the vessel in some instances of aneurysm of the aorta or innominate artery. The common trunk has been secured to restrain hæmorrhage, and to limit growth in the case of certain malignant tumours, and to check bleeding during the removal of such growths. The ligature of the carotid as a means of treating epilepsy has been abandoned as useless.

I have advocated the application of a temporary ligature or loop to the common carotid in instances where a permanent occlusion of the artery is not essential (*Lancet*, January, 1888).

The common carotid appears to have been first secured for hæmorrhage by Abernethy, in 1798 ("Surgical Works," vol. ii.). The patient died. The ligature was successfully applied (for hæmorrhage) in 1803 by Fleming (*Med.-Chir. Journal*, vol. iii.). Astley Cooper was the first surgeon to employ ligature of the common carotid as a means of treating aneurysm. His first operation was performed in 1805, and ended fatally (*Med.-Chir. Trans.*, vol. i.). His second case (1808) recovered.

The common carotid may be secured at any part of its course in the neck. The operations resolve themselves, however, into ligature above the omo-hyoid muscle and ligature below it. The former situation is in every respect to be preferred. Below the muscle the vessel is deeply placed, and

has more complicated relations to structures of importance. Farabeuf has well said that "below the omo-hyoid muscle the deaths are more numerous than the recoveries; above, the recoveries preponderate over the deaths."

Position.—The patient lies upon the back, close to the edge of the table, with the shoulders raised and the hand of the affected side placed behind the back. The chin should be drawn up and the head turned a little to the opposite side. The surgeon stands upon the side exposed for operation.

Ligature at the Place of Election (above the Omo-hyoid Muscle).—*Operation.*—The position of the cricoid cartilage having been defined, and the situation of the superficial veins made evident, an incision, about three inches in length, is made in the line of the artery, and is so placed that its centre is on a level with the cricoid cartilage (Fig. 39).

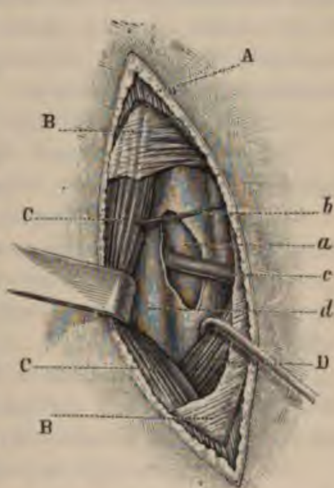

Fig. 39.—LIGATURE OF THE RIGHT COMMON CAROTID ABOVE THE OMO-HYOID.

A, Platysma; B, Cervical fascia; C, Sterno-mastoid; D, Omo-hyoid; *a*, Common carotid; *b*, Sterno-mastoid artery; *c*, Sup. thyroid vein; *d*, Internal jugular vein.

The skin and platysma having been incised (together with branches of the superficial cervical nerve), the surgeon divides the deep fascia along the anterior border of the sterno-mastoid muscle. Along this border a communicating vein between the facial and the anterior jugular may be met with. The edge of the muscle is defined, and is followed until the omo-hyoid muscle is made out. The superior border of this structure must then be well exposed, and the angle at which the two muscles meet be clearly demonstrated. The sterno-mastoid may be drawn a little outwards, and the omo-hyoid downwards.

The pulsations of the artery should now be sought for, and the vessel can usually be easily detected, as it crosses the conspicuous "carotid tubercle."

The artery is very mobile, and slips readily to and fro under the finger. If the pulse be feeble it may present the physical characters of a flat cord.

In exposing the sheath of the artery, care must be taken to avoid the sterno-mastoid vessel and the superior or middle thyroid veins.

The sheath should be opened upon the inner side, and precaution taken not to damage the descendens noni nerve. Holding the sheath by the inner lip of the wound which has been made in it, the surgeon, with an unthreaded aneurysm needle, should clear the artery upon its inner side. Holding, then, the outer lip of the sheath in the forceps, the outer side of the vessel can be cleared. By shifting the forceps as required, the whole circumference of the artery can be separated from its sheath. This process must be carried out with great care and with thoroughness.

The needle is passed from without inwards, is then threaded and withdrawn, bringing the ligature with it.

Comment.—In uncomplicated cases the operation is very simple. If the tissues are matted together, or are encroached upon by pus or blood, or are displaced by a tumour or growth, the procedure may be attended with no little difficulty and risk.

If the head be turned too much to the opposite side, the sterno-mastoid is carried unduly far over the artery, and the border of the muscle may be missed.

The operation may be much complicated by the presence of large or distended veins. The internal jugular vein is of considerable size, is very thin, and is readily wounded. Its proportions are influenced by the respiratory movements, and, when the breathing is embarrassed, it becomes at one time enormously swollen, and at another moment flat and comparatively small.

The needle must be passed with great care. The artery has been transfixed by a needle which has been very roughly used. The descendens noni, the pneumo-gastric, and even the sympathetic cord, have been accidentally included in the ligature.

2. Ligature below the Omo-hyoid Muscle.

Operation.—The position of the patient is the same as in

the previous operation. The incision is three inches in length, is in the line of the artery, and is so disposed as to commence a little below the level of the cricoid cartilage, and end a little above the sterno-clavicular joint. It follows the inner border of the sterno-mastoid muscle. Care must be taken to avoid the communicating vein from the facial, already described, and also the anterior jugular vein.

The sterno-mastoid is exposed and drawn outwards. The sterno-hyoid and sterno-thyroid muscles are likewise made evident, and are drawn inwards. The omo-hyoid, if seen, is relegated to the upper part of the wound.

It may be necessary to divide the sternal part of the sterno-mastoid, and the whole or parts of the sterno-hyoid and sterno-thyroid muscles, especially if the ligature has to be applied as low down as possible. Retractors are needed to draw the muscles aside, and a good light is essential.

The inferior thyroid veins may prove very troublesome.

The sheath is opened on its inner side, as already described, and the needle is passed from without inwards.

Comment.—The observations made upon the previous measure apply in the main to the present proceeding.

The depth at which the vessel is placed renders the operation difficult and dangerous, and on the left side the surgeon's movements are apt to be complicated by the position of the internal jugular vein.

The relations of the inferior thyroid artery, and of the recurrent laryngeal nerve, must be borne in mind.

Collateral Circulation after Ligature of the Common Carotid.

Cardiac Side.		*Distal Side.*
Inferior thyroid	with	Superior thyroid.
Deep cervical	with	Occipital.
Transversalis colli	with	Occipital.

The communications between the two vertebral arteries and the branches of the two external carotid arteries.

The communications effected by the circle of Willis.

Varieties of the Common Carotid Artery.

1. Variations in the origin of the vessels have little effect upon their course in the neck.

2. The innominate may bifurcate higher (as a rule, lower) than usual.
3. The artery may bifurcate as high up as the level of the hyoid bone, or as low as the level of the middle of the larynx, or even of the cricoid cartilage.
4. The place of the common carotid may be taken by two parallel vessels—the external and internal carotids.
5. From the upper part of the artery the superior thyroid, or ascending pharyngeal artery, may arise.
6. The vagus nerve has descended in front of the artery.

THE EXTERNAL CAROTID ARTERY (II.).

Anatomy.—This artery extends from the level of the upper border of the thyroid cartilage to the level of the neck of the inferior maxilla. It is somewhat tortuous, but when rendered straight measures about two and three-quarter inches. It diminishes rapidly in size as it ascends.

About its origin it is covered only by the integuments, the platysma, and the cervical fascia, and at the same part it is overlapped by the sterno-mastoid muscle. It soon becomes deeply placed, and passes beneath the digastric and stylo-hyoid muscles, and ultimately through a portion of the parotid gland. In its upper part, it is separated from the internal carotid by the styloid process, the stylo-pharyngeus muscle, and the glosso-pharyngeal nerve.

At the lower edge of the digastric muscle the hypoglossal nerve crosses in front of the artery. Below this nerve the facial and lingual veins cross the vessel on its anterior aspect. Some way above the digastric the glosso-pharyngeal nerve passes obliquely behind the external carotid. The infra-maxillary branches of the facial nerve are superficial to the artery above the digastric. The superior laryngeal nerve is placed obliquely behind the vessel near its origin.

The anterior division of the temporo-maxillary vein may pass with the artery beneath the digastric muscle. More usually it lies superficial to that vessel.

The superior thyroid arises directly from the artery at its

commencement. The lingual takes origin at a level with the greater cornu of the hyoid bone. The facial and occipital arise at the same level a little above the lingual.

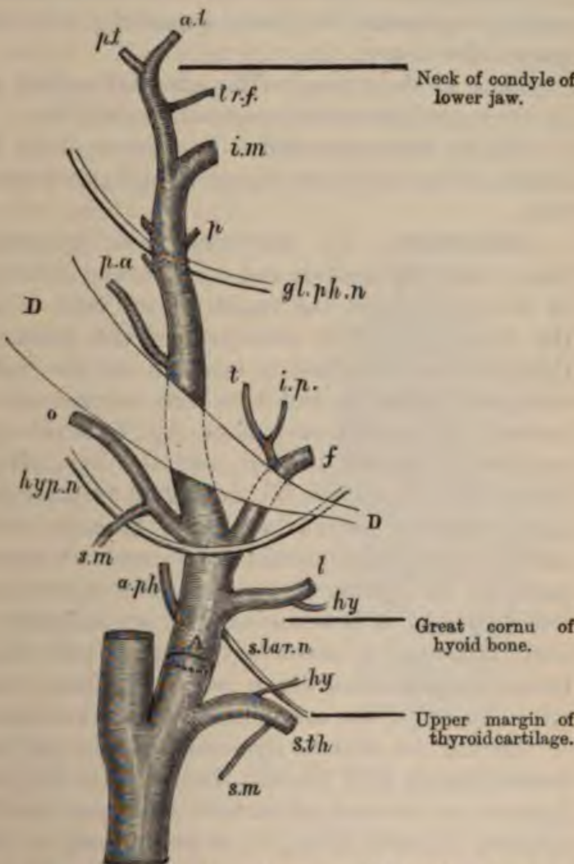

Fig. 40.—EXTERNAL CAROTID ARTERY, NATURAL SIZE. (*Modified from Quain.*)
A, Site of ligature; D, Digastric muscle.

Fig. 40 shows the artery at about its natural size, and serves to indicate the dimensions and position of the branches of the trunk, the intervals which separate their points of origin, and the relations of one branch to another. The more important landmarks in the course of the artery are also shown.

It will be observed that the digastric muscle crosses the

artery about one inch and a quarter above its origin from the common carotid, and that the hypoglossal nerve crosses at about the height of one inch.

The segment between the bifurcation and the digastric muscle represents the most superficial and most accessible part of the artery.

Line of the Artery.—The external carotid is represented by the upper part of the common carotid line.

Others have proposed a line drawn from the tip of the lobule of the ear to the tip of the greater cornu of the hyoid bone.

Indications.—The artery has been ligatured for hæmorrhage following wounds and injuries, and involving the trunk or the branches of the vessel, for the cure of aneurysm and the relief of cirsoid aneurysm of the scalp. It has been ligatured as a palliative measure in the case of certain malignant growths, and has been secured as a preliminary measure to certain operations, *e.g.*, removal of the maxilla, excision of parotid tumour, and the like. Harrison Cripps (*Med.-Chir. Trans.*, vol. lxi., page 234) very properly urges that in all cases of hæmorrhage from branches of the external carotid that vessel should be secured whenever possible, in place of the common carotid. The operation is certainly less easy, but it is attended with an infinitely smaller mortality, the risks of secondary bleeding are reduced, and the brain complications, which are so frequent a cause of death after ligature of the common trunk, are avoided.

Among the first to ligature the external carotid Chelius names Bushe, 1827 (*Lancet*, 1827-8, page 482), who applied a ligature on account of cirsoid aneurysm, and Lizars, 1829 (*Lancet*, 1829-30, page 54), as preliminary to removal of the upper jaw.

Operation.—The position of the patient and of the operator should be the same as is observed in the previous operation.

The "place of election" is represented by the portion of the vessel between the superior thyroid and lingual arteries.

An incision, two and a half to three inches in length, is made in the line of the artery from a point about on a level with the middle of the thyroid cartilage to near the angle of

the jaw. The greater cornu of the hyoid bone will be about the centre of the incision.

The integuments and platysma having been divided, and any superficial vein secured, the fascia is cut through, and the anterior border of the sterno-mastoid is exposed in the lower part of the wound. This muscle must be drawn outwards. The posterior belly of the digastric should next be sought for at the upper angle of the wound, and below it the hypoglossal nerve should be made evident. The surgeon now seeks with the finger for the tip of the great cornu of the hyoid bone, and when this is discovered all the "points" leading to the artery are in evidence (Fig. 41).

The artery should now be exposed opposite to the level of the tip of the great cornu, and between the origins of the superior thyroid and lingual arteries. In this part of the operation care must be taken to avoid the facial and superior thyroid veins. Lymphatic glands may lie in front of the vessel. The artery having been cleared, the needle is passed from without inwards. In effecting this, great care must be taken to avoid the superior laryngeal nerve, which courses behind the artery in this situation.

Fig. 41.—LIGATURE OF RIGHT EXTERNAL CAROTID.

A, Platysma; B, Cervical fascia; C, Sterno-mastoid; D, Digastric; E, Great cornu of hyoid bone; *a*, External carotid at origin of superior thyroid; *b*, Crossing lingual artery points to lingual vein; *c*, Facial artery; *d*, Facial and superior thyroid veins; 1, Hypoglossal nerve.

Jacobson advises that the superior thyroid and lingual, and, if possible, the ascending pharyngeal arteries, should be secured at the same time, to minimise the risk of secondary hæmorrhage.

Comment.—This operation is somewhat difficult, on account of the complicated relations of the artery, and the fact that the branches are not always readily identified.

The artery has been ligatured above the digastric; but the procedure is still more difficult, and is attended with several special risks. The operation "behind the ramus of the jaw" is thus described by Jacobson:—"This operation has the disadvantage of probably entailing the division of important branches of the facial nerve. The head and shoulders being duly raised and supported, the surgeon makes an incision downwards from the tragus of the ear, just behind the ramus of the jaw, dividing the skin and fasciæ. The sterno-mastoid must now be drawn outwards, and the digastric and stylo-hyoid downwards, and it will probably be needful to divide these muscles partially, in order to secure the artery before it enters the parotid gland, this structure being drawn upwards and forwards. The needle may be passed from either side, as is most convenient to the surgeon.

"Several veins communicating between the facial and the external jugular will probably cross the line of incision, and must be dealt with."

Collateral Circulation after Ligature of the External Carotid.—(*See* the collateral circulation after ligature of the common carotid.)

Varieties of the External Carotid.

1. *See* the varieties of the common carotid.
2. The branches of the artery may be crowded together near the commencement of the trunk.
3. The number of branches may be diminished; two or three arising from one trunk.
4. The number of branches may be increased; subsidiary vessels arising from the main artery.

THE INTERNAL CAROTID ARTERY (II.).

Anatomy.—In its course in the neck this artery extends from the bifurcation to the carotid canal in the petrous bone. The vessel lies at first a little behind the external carotid, and slightly to its outer side.

The first part of the vessel is comparatively superficial, and is the only portion to which a ligature can conveniently be applied. This portion, which is not more than one inch and a quarter in length, is covered by the integuments, platysma and deep fascia, and is overlapped by the sterno-

mastoid. The artery soon becomes more deeply placed by passing beneath the digastric, stylo-hyoid, and stylo-pharyngeus muscles, and with this segment we have no concern. The internal jugular vein is close to the artery, lying to its outer side below, and a little to the postero-external aspect as the skull is reached. The vessel lies upon the spine and rectus capitis anticus major, and is in close relation with the pharynx. It is invested in a sheath, which encloses also the vein and the vagus nerve, the latter structure being posterior to both the vessels.

The superior cervical ganglion lies behind the commencement of the artery (corresponding to the first three cervical vertebræ), and is separated from it by the superior laryngeal nerve.

The *Line of the Artery* is practically identical with that for the external carotid.

Indications.—This vessel has been but very rarely ligatured. It has been secured in cases of hæmorrhage following injury, and notably punctured wounds, and also in cases of traumatic aneurysm.

The internal carotid was ligatured by Keith, of Aberdeen, in 1851 (Ashhurst's "Encyclopædia of Surgery," vol. iii., page 294).

Dr. Lee, of Kingston, United States, secured the artery by two ligatures, in a case of stab of the neck, in 1869. The patient recovered (*ibid.*).

Dr. Briggs, of Nashville, United States, tied the artery on the distal and proximal side of a traumatic aneurysm with success, in 1871. He ligatured the common carotid at the same time (*Amer. Journ. of the Med. Sc.*, Jan., 1879), and in 1874 Dr. Sands, of New York, secured the artery above and below the bleeding point, in a case of secondary hæmorrhage, following an operation for the removal of the lower jaw. The case was successful (*New York Med. Journ.*, Jan., 1874).

Operation.—The position of the patient and the surgeon is the same as is observed in the operations upon the common or external carotid.

The internal carotid is secured only at its commencement, close to the bifurcation, and the operation is, in all essential features, identical with that employed in ligaturing the external carotid at the place of election.

The incision is of the same length, and occupies the same position in the neck, so far as the vertical line is concerned. It is placed over the anterior edge of the sterno-mastoid (with which it is parallel), and is therefore a little external to the incision required for the external carotid.

The muscle is drawn outwards. The external carotid is sought for and exposed, and then the operator brings into view the internal trunk. The former vessel is drawn inwards with a small blunt hook, the latter outwards. The digastric muscle is drawn upwards.

The sheath of the vessels is opened with care, and directly over the artery. The needle is passed from without inwards, with the same precautions as are observed in ligaturing the common carotid. Care must be taken to avoid injury to the internal jugular vein, the vagus nerve, the sympathetic ganglion, and the ascending pharyngeal artery, all of which are very close to the vessel at the seat of ligature.

Collateral Circulation after Ligature of the Internal Carotid.—The circulation between the two internal carotids and the vertebrals is exceedingly free through the circle of Willis.

Varieties of the Internal Carotid Artery.

1. The cervical part may be unduly tortuous.
2. The artery has, in rare cases, been absent.
3. It has given off, from its lower part, the occipital or the ascending pharyngeal arteries.

THE SUPERIOR THYROID ARTERY (IV.).

Anatomy.—This vessel is the first branch of the external carotid, and arises close to the bifurcation, and a little way below the greater cornu of the hyoid bone. It curves, at first, a little upwards, and then runs downwards and forwards (Fig. 40).

It is only superficial at its commencement. It is in close relation behind with the superior laryngeal nerve. Its first branch is the hyoid, and its second—which is close to it—is the sterno-mastoid. The former, as a rule, arises about a quarter of an inch from the point of origin of the superior thyroid. A more considerable interval intervenes between the sterno-mastoid artery and the next branch, the superior aryngeal.

The ligature is most conveniently applied between these two branches.

The superior thyroid artery varies much in size. There may be two vessels, or a single trunk may arise from the common carotid or lingual arteries.

Operation.—The operation is in all essential particulars identical with that employed in exposing the external carotid at the place of election (Fig. 41).

The incision is about two inches in length, and is so placed along the carotid line that the centre of the cut is on a level with the upper margin of the thyroid cartilage. The external carotid should be made evident, and the superior thyroid traced from it. The ligature may be applied close to the external carotid, between it and the hyoid branch, or, preferably, nearer to the larynx, and beyond the origin of the sterno-mastoid artery.

The superior thyroid veins, which often have a plexiform arrangement, may complicate the operation. The needle may be passed from above downwards. Care must be taken to avoid the superior laryngeal nerve.

THE LINGUAL ARTERY (IV.).

Anatomy.—This artery arises nearly opposite to the greater cornu of the hyoid bone, and about three-quarters of an inch above the bifurcation of the carotid. It ascends a little, and then, passing downwards and forwards, forms a curve (Fig. 40). It soon disappears beneath the digastric and stylo-hyoid muscles, and running forwards under the hyo-glossus, and along the upper border of the greater cornu of the hyoid bone, it reaches the anterior margin of that muscle, where it turns upwards to enter the under surface of the tongue.

The *first part* of the vessel extends from its origin to the posterior margin of the hyo-glossus muscle (kerato-glossus).

The *second part* is that which lies under the hyo-glossus muscle; and the *third part* is that slender portion of the vessel which extends beyond the anterior margin of the muscle (basio-glossus).

The *first part* is covered by the skin, platysma, and deep fascia, and by some of the cervical glands. It forms a kind of loop, which is crossed by the hypoglossal nerve, and by

the facial and lingual veins. The digastric and stylo-hyoid muscles cross this segment of the artery before the hinder border of the hyo-glossus is reached.

This part of the lingual lies behind, upon the middle constrictor and the superior laryngeal nerve.

From the first part arise the hyoid and dorsalis linguæ branches, the former about half an inch from the origin of the artery, the latter near to the posterior border of the hyo-glossus, under cover of which border it ascends to the tongue.

The hyoid branch is inconstant, and may be absent.

The *second part* of the lingual lies beneath the hyo-glossus, and has a nearly horizontal course. It rests upon the genio-glossus, and is placed below the level of the hypoglossal nerve, which is entirely superficial to it. The sublingual branches arise from this part, taking origin near the anterior border of the hyo-glossus muscle.

The *third part* of the artery takes the name of the ranine, and is distributed to the tongue.

The *veins* attending the lingual artery are divided into three sets. 1. The ranine vein, the largest, has a course independent of the artery. It runs on the superficial surface of the hyo-glossus, below the hypoglossal nerve, and about on a level with the lingual artery, which is beneath the muscle. 2. Two very small venæ comites accompany the artery in its course beneath the hyo-glossus. 3. Several veins usually attend the dorsalis linguæ artery, and often have a plexiform arrangement. These three sets of veins may enter into a common trunk, the lingual vein, but very frequently they enter separately into the internal jugular, or common facial veins.

The lingual artery may arise from the superior thyroid, or from the facial, or it may be replaced by a branch of the internal maxillary artery.

The vessel may run between the fibres of the hyo-glossus muscle, close to its origin from the bone.

Indications.—The lingual has been ligatured in cases of hæmorrhage following wound of the artery or its branches. The ligature has been employed to arrest bleeding in advanced cancer of the tongue, and to modify the growth of the cancer in cases unfitted for other operation. The lingual has been

secured in the treatment of macroglossa. The most common circumstance, however, under which this vessel is tied, is as a preliminary measure in the removal of the tongue.

The artery may be secured in either the first or the second part of its course. In the former situation a ligature is but very rarely applied, the place of election being in the second segment of the vessel as it lies beneath the hyo-glossus muscle, and occupies the digastric triangle.

The operation for the ligature of the first part is ascribed to Charles Bell (1814), and that for the securing of the lingual at the place of election to Pirogoff (1836).

1. Ligature of the Artery at the "Place of Election," *i.e., beneath the hyo-glossus muscle.*

Position.—The patient lies close to the edge of the table, with the shoulders raised, with the arm of the affected side passed behind the back, and with the face turned to the opposite side. An assistant must keep the chin drawn well upwards, and the lower jaw fixed. The surgeon stands upon the side to be operated upon. The chief assistant is placed opposite to him, and leans over the patient's body. A second assistant stands by the surgeon's side. His chief duty is to hold the hook which commands the digastric tendon. The patient must be well anæsthetised before the operation is commenced. In male subjects the skin of the submaxillary region should be shaved.

Operation.—An incision, some two inches in length, curved, and with the convexity downwards, is made between the lower jaw and the hyoid bone. The wound commences a little below and to the outer side of the symphysis, and ends a little below and to the inner side of the point where the facial artery crosses the lower margin of the maxilla. Its centre is just above the greater cornu of the hyoid bone (Fig. 36). On the right side the incision is made from behind forwards, on the left side from before backwards.

The integuments, platysma, and superficial fascia are divided in the line of the incision. Certain superficial veins will be encountered, and some will probably have to be secured. These veins are the submental or other tributary of the facial, or some tributary of the anterior jugular.

It will now be convenient to apply ligature retractors (*see*

page 55) in order that the depths of the wound might be well laid open.

The next step is to fully expose the submaxillary gland. It is lodged in a special compartment of the cervical fascia. This fascia should be opened transversely over the lower part of the gland, and the organ should be cleared and brought well out into the wound by means of the finger and the handle of a scalpel. The gland should be turned upwards on to the margin of the jaw, and be kept out of the operation area by means of a broad and well-curved retractor held by the chief assistant.

The fascia exposed by the lifting out of the salivary gland is now to be divided transversely, and in the anterior angle of the wound the posterior edge of the mylo-hyoid muscle must be sought for and defined.

The digastric tendon and the two bellies of the muscle are now to be brought clearly into view. Around the tendon, where it is nearest to the hyoid bone, a small blunt hook with a very long shaft or handle is to be passed and held by the assistant who stands at the surgeon's side. The tendon should be drawn downwards and towards the surface.

By this means the area of the operation is brought well into view, and is increased in extent; the parts are fixed; the hyoid bone, carrying with it the hyo-glossus muscle, is brought nearer to the surface, and the muscle in question is put upon the stretch.

The hyo-glossus muscle can be now easily made out, and its exposed surface freed of connective tissue. The hypoglossal nerve must be sought for, as it crosses the muscle, and the surgeon's work be limited to the segment of muscle below the nerve (Fig. 42).

Crossing the hyo-glossus below the nerve, and parallel with it, is the ranine vein. This vein will about correspond in position with the artery, which lies beneath the muscle.

The vein and the nerve should be displaced upwards.

The hyo-glossus muscle is divided transversely to the extent of about half an inch, a little above the margin of the hyoid bone, and parallel with it.

The incision in the muscular tissue must be cautiously deepened. If the cut has been well placed, the artery will

bend out into the wound and make itself evident as soon as the whole thickness of the muscle has been divided.

The needle—unthreaded—is most conveniently passed from above downwards. In the ligature the minute venæ comites which attend the artery are no doubt included.

The wound is gently washed out, and the gland replaced. The edges of the incision are adjusted by sutures, but no drainage-tube is required.

Comment.—This operation requires a good light, and is only performed with ease and certainty when the procedure is carried out step by step.

The stages of the operation should be marked in succession by the following points: 1. The complete lifting up of the submaxillary gland. 2. The demonstration of the edge of the mylo-hyoid muscle. 3. The clearing of the digastric tendon, and the drawing of it outwards with a hook. 4. The demonstration of the hypoglossal nerve on the hyoglossus muscle.

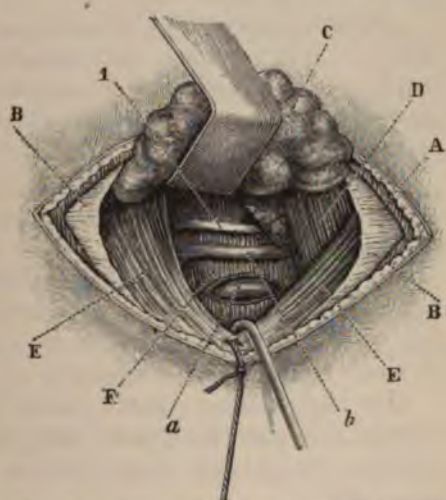

Fig. 42.—LIGATURE OF RIGHT LINGUAL ARTERY

A, Platysma; B, Cervical fascia; C, Submaxillary gland; D, Mylo-hyoid; E, Digastric; F, Hyoglossus; *a*, Lingual artery; *b*, Ranine vein; 1, Hypoglossal nerve.

The incision may be of less dimensions than those given, or may be extended if required.

If the cut be carried too far back, the facial vein and artery are endangered. Time should not be wasted over the early part of the operation. Such veins as are cut may be clamped and left. They seldom require a ligature. The gland must be well exposed. The chief difficulties of the operation depend upon the gland. I have ligatured the lingual more than sixty times (all in cases of carcinoma of the tongue), and have come to regard the state of the salivary gland as the

main element of uncertainty in the procedure. This gland varies in size, in density, and in the closeness of its attachments. These variations are probably never normal, but are incident to changes connected with cancer of the tongue.

It is most important that the gland be neither wounded nor damaged, as a temporary salivary fistula may possibly follow.

As soon as the gland has been turned out of its bed, steps must be taken to keep the wound quite bloodless. Other complications are afforded by a matting together of parts by a past inflammation, by the presence of unusual veins, or of enlarged lymphatic glands.

As the wound becomes deep, and the area of the operation very narrow, a pair of long-bladed and fine dissecting forceps is needed.

The fixing of the digastric tendon and the hyoid bone by means of the small hook is an essential part of the operation. Embarrassed breathing may form a serious complication in the later stages of the procedure.

The hyo-glossus muscle varies in thickness; the part divided is, in the main, the basio-glossus, and the beginner will find the muscle much thicker, probably, than he had imagined.

The lingual has been cut in dividing the muscle carelessly. The bulging of the artery into the wound in the muscle is very characteristic whenever the incision has been fortunate enough to be accurately placed. I know of no artery which, when exposed by operation, looks less like an artery than the lingual.

2. **Ligature of the Artery at its First Part.**

Operation.—The patient's position is the same as is observed in ligature of the external carotid.

The same incision may be used as is employed in securing that artery. The cut, however, should be shorter, and be so placed that its centre is opposite to the body of the hyoid bone.

After the superficial structures have been divided, the external carotid should be sought for, and followed until the lingual is reached (Fig. 41).

Or an incision about one inch and a half long may be made transversely in the neck, just over the greater

cornu of the hyoid bone. This cut should be slightly convex downwards, and should extend from the level of the body of the hyoid bone to the margin of the sterno-mastoid muscle. The integuments, platysma, and fascia having been divided, the greater cornu of the hyoid bone is sought for. The submaxillary gland is displaced upwards. The hypoglossal nerve is demonstrated, and the artery exposed just at the anterior border of the hyo-glossus muscle, and secured before it has passed beneath that structure.

Comment.—These operations are dangerous and difficult. The ligature is applied to the trunk on the proximal side of the dorsalis linguæ, but this advantage is of no great value, as I am not aware that any difficulty has arisen from leaving the dorsalis linguæ unsecured. The situation has many disadvantages. The origin of the lingual is subject to variation. The ligature is applied close to the main artery. The wound is deep, and the artery is not supported upon any resisting structure. Numerous veins, moreover, more or less entirely obscure the first portion of the vessel.

LIGATURE OF OTHER BRANCHES OF THE EXTERNAL CAROTID.

The facial, temporal, or occipital arteries may require to be ligatured in cases of wound, and in still rarer instances of traumatic aneurysm. The two latter vessels have also been secured in the treatment of cirsoid aneurysm of the scalp.

It is unnecessary to detail in precise manner the various steps involved in the securing of these and other of the smaller arteries of the head and neck.

In most instances the operation is informal, and consists merely in picking up a bleeding vessel at the bottom of an existing wound, which, at the most, has been merely enlarged.

The Facial Artery (IV.) has been ligatured in the neck, through an incision similar to that employed in exposing the external carotid artery, or the commencement of the lingual (Fig. 41). It is, however, most conveniently secured as it crosses the lower margin of the jaw (Fig. 43). A horizontal incision, one inch in length, is made across the course of the vessel, along, and under cover of, the inferior margin of the jaw. The artery crosses this margin at the anterior border of the masseter muscle. After the skin, platysma, and fascia

have been divided, the artery should be in evidence, especially as its pulsations are readily felt. The facial vein is behind the artery, and very close to it. The needle should be passed from behind forwards.

A vertical incision in the course of the artery has been

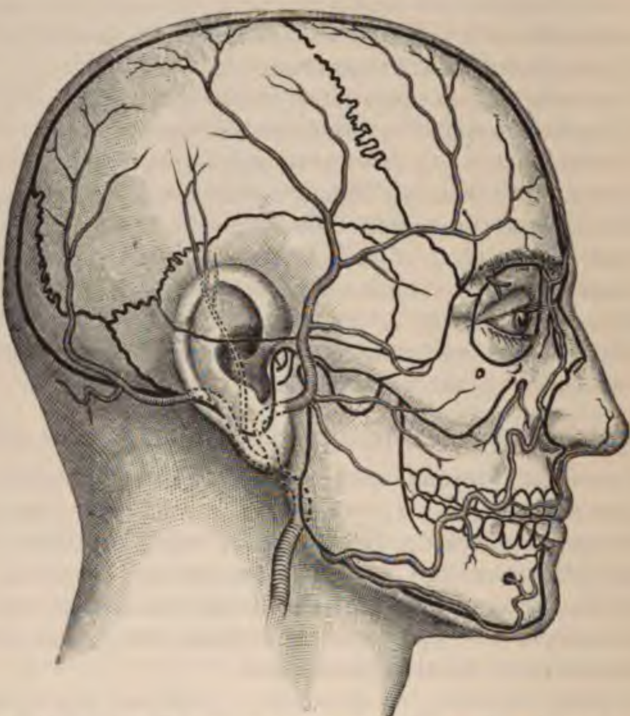

Fig. 43.—DIAGRAM TO SHOW THE POSITION OF THE FACIAL, TEMPORAL, AND OCCIPITAL ARTERIES. (*Modified from Merkel.*)

advised; but it exposes the vessel in a less convenient manner, and leaves a more conspicuous scar.

The Temporal Artery (IV.) may be secured just in front of the meatus, as the vessel leaves the parotid gland. An incision one inch in length is made vertically, over the course of the vessel, between the tragus and the condyle of the jaw. The artery is ligatured just above the root of the zygoma (Fig. 43). It is here covered by the skin and a dense fascia. A

single large vein accompanies it, lying behind the artery and overlapping it. The vessel is crossed by branches of the temporo-facial division of the facial nerve, and lies over and behind the auriculo-temporal nerve. The needle is passed from behind forwards.

The temporal bifurcates about one inch and a quarter above the root of the zygoma.

The Occipital Artery (IV.) has been ligatured close to its origin, and also in that part of its course which lies beyond the mastoid process (Fig. 43). In the first position it is reached by an incision similar to that employed for exposing the external carotid (Fig. 41). That vessel is made evident, and the hypo-glossal nerve, which winds round the occipital, is demonstrated.

In the second position a nearly horizontal incision, two inches in length, is made, which, commencing about the tip of the mastoid process, is carried backwards and a little upwards. The skin and fascia having been divided, the muscles are exposed. The posterior fibres of the sterno-mastoid must be divided; the splenius is then cut, and so much of the trachelo-mastoid as may be necessary. The surgeon now feels for the interval between the mastoid process and the transverse process of the atlas, and exposes the artery as it escapes from beneath the digastric muscle.

A good light and suitable retractors are needed for this operation. Two small venæ comites attend the artery. Care must be taken not to injure the veins issuing from the mastoid foramen. The needle may be passed either from above or from below.

CHAPTER IV.

LIGATURE OF THE ARTERIES OF THE LOWER LIMB.

THE DORSALIS PEDIS ARTERY (IV.-V.).

Anatomy.—The artery extends from the bend of the ankle to the posterior end of the first interosseous space. It lies on the tarsal bones—to which it is attached by an aponeurotic layer—between the tendons of the extensor pollicis and extensor communis digitorum. It passes beneath the lower band of the annular ligament and the dorsal fascia of the foot. Near its termination it is crossed by the innermost slip of the extensor brevis digitorum.

Two venæ comites accompany the artery, and the inner branch of the anterior tibial nerve lies to its outer side. Occasionally the nerve is superficial to the artery.

Varieties of the Dorsalis Pedis Artery:

1. The artery may be wanting and its place be supplied by the anterior peroneal.
2. It may curve outwards below the ankle-joint, and return to its normal position at the back of the first space.
3. It may pass through the second space.

Line of the Artery.—From the centre of the front of the ankle—the centre of the inter-malleolar space—to the middle of the first interosseous space.

Operation.—The patient lies upon the back. The limb is straight and the heel is steadied firmly on the table. The surgeon stands to the outer side of the limb in each case, cutting from above downwards on the right side and from below upwards on the left. One assistant stands on the opposite side of the table to steady the limb and to hold the foot in the position of full extension. Another assistant attends to the wound.

An incision, one inch and a half long, is made on the line of the artery, and commences at the lower border of the annular ligament. The cut will be midway between the tendon of the extensor pollicis and the innermost tendon of the extensor communis (Fig. 44). The dorsal fascia of the foot is divided in the same line. The artery—often buried in much connective tissue—is found lying close to the bone. The ankle should be a little relaxed from the extended posture as the artery is sought for. The needle should be passed from the outer side to avoid the nerve.

Comment.—The operation is seldom required except to tie a bleeding point. Aneurysm of the dorsalis pedis is not exceedingly rare. The tumour is usually placed over the scaphoid or internal cuneiform bone. Ligature of the artery above and below the aneurysm has been fairly successful. The inner division of the musculo-cutaneous nerve will be exposed in the subcutaneous tissue, and must be avoided. Care should be taken not to open the synovial sheaths of the two tendons between which the artery lies. The tarsal branch of the vessel arises opposite the head of the astragalus, and the metatarsal branch opposite the bases of the metatarsus.

THE ANTERIOR TIBIAL ARTERY (IV.).

Anatomy.—The vessel lies at first close to the inner side of the neck of the fibula. As it descends it gradually approaches the tibia, and at the lower third of the leg it lies in front of that bone. In the upper two-thirds of the leg, the artery rests on the interosseous membrane, to which it is closely bound by connective tissue. It is at first very deeply placed, but at the lower third of the limb it becomes superficial. For the upper fourth the vessel lies between the tibialis anticus on the inner side and the extensor communis on the outer side. From thence to the lower end of the middle third of the leg it lies between the tibialis anticus and the extensor communis and extensor proprius pollicis, the latter being the more deeply placed. In the lower third, where the muscles become tendinous, it is crossed gradually by the extensor pollicis tendon, which ultimately lies to its inner side. The vessel here passes under the upper band of the annular ligament.

Two venæ comites accompany the vessel, one lying in front of the artery, the other behind it. The anterior tibial nerve lies first to the outer side of the artery, then (for the greater part of its course) more or less in front of the vessel, and lastly once more to its outer side.

Line of the Artery.—From a point midway between the head of the fibula and the outer tuberosity of the tibia, to the centre of the front of the ankle-joint.

Fig. 44.—LIGATURE OF THE ANTERIOR TIBIAL ARTERY, AND OF THE DORSALIS PEDIS.

Indications.—The artery may be ligatured at any part of its course on the front of the leg. The ligature in the lower third is the most common. It is performed here for wound or for aneurysm. Ligature of the artery above the lower third is seldom called for, and is probably limited to cases of wound only. Aneurysms are rare, and are most usually met with at either the upper or the lower end of the artery, and not about the middle of its course. Ligature of the vessel in its lower third may be an auxiliary measure in some cases of bleeding from the foot. In punctured wounds of the upper third of the limb great doubt may exist as to which artery is divided, the anterior or the posterior tibial. In such instances it is a question whether position and pressure, followed possibly by the distal ligature, do not form a better measure than a widely extended dissection in search of the bleeding point.

1. Ligature in the Upper Third of the Leg.

Position.—The patient lies upon the back. The limb is straight upon the table. The foot projects beyond the end of the table, and is forcibly extended, and (with the leg) fully rotated inwards. The surgeon stands always to the outer side of the limb. The incision for the right artery is made from

above down; for the left, from below up. Two assistants stand on the opposite side of the table—one steadies the leg and manipulates the foot, the other attends to the wound.

Operation.—Before anæsthetising the patient, the outer margin of the tibialis anticus should be, if possible, defined by causing the patient to contract the muscle.

An incision, three and a half inches in length, is made precisely along the line of the artery (Fig. 44). Its upper end will be about one inch below the head of the tibia. The deep fascia is exposed, and is divided along the same line. The interval between the tibialis anticus and extensor communis digitorum is made out. The foot is now flexed to relax these muscles. The space between them is opened up by means of the finger and handle of the scalpel. In doing this, the external border of the tibia is aimed for, and should be distinctly felt before the artery is sought. In proceeding towards this border, the extensor communis is held down by the first two fingers of the left hand, while the assistant holds the tibialis anticus towards the tibia with a retractor. The outer border of the tibia having been made out with the forefinger, the artery will be found to the outer side of it, lying on the interosseous membrane. It is covered and held down by a moderately dense connective tissue. The artery is now exposed, a second retractor being used to repress the extensor communis (Fig. 45).

Fig. 45.—LIGATURE OF RIGHT ANTERIOR TIBIAL ARTERY (UPPER THIRD).

A, Fascia of leg; B, Tibialis anticus; C, Extensor communis digitorum; *a*, Anterior tibial artery; *b*, Anterior tibial veins; 1, Anterior tibial nerve.

The venæ comites lie so close to the artery, and in such a position (*see* page 174), and send so many transverse branches across it, that it is practically impossible to certainly separate them. They will be probably enclosed in the ligature. The

nerve lies to the outer side of the artery. The needle is passed from without inwards.

The nerve may not be seen. It may not join the artery until the middle third of the limb is reached. It, however, usually meets the vessel at the junction of the upper with the second fourth.

Comment.—The only difficulty in this operation is the finding of the gap between the tibialis anticus and the extensor communis digitorum. Not the least indication of it exists upon the surface of the deep fascia. The "white line" described by some authors is a myth, so far at least as this segment of the limb is concerned. On the other hand, there is a distinct septum between the extensor communis and the peroneus longus. This is indicated by a white line often marked by a deposit of fat, and also by the escape of cutaneous vessels. The fascia to the inner side of this line is dense, and is composed of oblique fibres all running downwards and inwards. This is the fascia covering the tibialis anticus and the common extensor. The fascia to the outer side of the line—that covering the peronei—is thinner, and made up mainly of longitudinal fibres crossed by a few transverse streaks.

In seeking the proper muscular interval, the following points may be observed:—Incise the fascia precisely in the "line of the artery." That line corresponds to the gap between the two muscles. In a muscular subject the fascia may be divided by a second cut at right angles to the first. Bear in mind that the gap may not be evident even after a liberal turning back of the fascia. The fibres of the two muscles have the same direction, and the outer edge of the tibialis anticus may overlap the border of the extensor communis. There is usually a slight septum between the two muscles, but it is limited to the upper third of the limb, or even the upper fourth or upper sixth. From an operative point of view it is not to be relied upon. The gap required is to be felt rather than seen. No attempt should be made to demonstrate it by cutting. The forefinger and handle of scalpel should alone be used. The gap lies about a finger's breadth from the septum between the extensor communis and the peroneus longus, and about an inch or an inch and a quarter from the tibial crest.

It can be best made out by pressing the forefinger along the muscles lengthways, when it is appreciated as the line of least resistance.

2. **Ligature in the Middle Third of the Leg.**

Operation.—The position is the same as in the above operation. Make an incision three inches in length along the line of the artery (Fig. 44). The deep fascia is exposed. The interval between the tibialis anticus and extensor communis is indicated by a yellowish-white line. This is due, not to a distinct septum, but to a line of fatty tissue lodged between the two muscles. In emaciated subjects the line may not be apparent. The deep fascia is divided along this line. The two muscles above-named are found lying close together. The outer edge of the tibialis anticus is still muscular, but the inner edge of the common extensor is now tendinous.

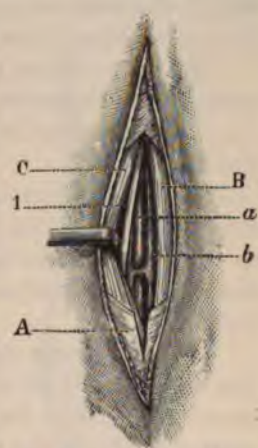

Fig. 46.—LIGATURE OF RIGHT ANTERIOR TIBIAL (LOWER THIRD).

A, Anterior annular ligament; B, Tibialis anticus; C, Extensor proprius pollicis; *a*, Anterior tibial artery; *b*, Anterior tibial veins; 1, Anterior tibial nerve.

Flex the foot. Separate the muscles with the handle of the scalpel, keeping in the direction of the tibia. The artery is found upon the interosseous membrane, with the still deeply placed extensor pollicis to its outer side. The nerve will be exposed before the artery is reached, since it here usually lies in front of the vessel. The needle may be passed from either side. It may be impossible to separate the venæ comites, but great care must be taken to avoid the nerve. In the living subject persistent attempts to separate the venæ comites will probably only lead to laceration of those vessels.

3. **Ligature in the Lower Third of the Leg.**

Operation.—The position is the same, only the foot need not be so much rotated in.

An incision, two to two and a half inches in length, is made in the line of the artery, and just to the outer side of the tendon of the tibialis anticus

The tendon must be identified beyond doubt before the operation is proceeded with. The deep fascia—here known as the upper band of the anterior annular ligament—is divided in the same line; and the space between the tibialis anticus tendon and the tendon of the extensor pollicis is defined. Both these tendons will be exposed. The artery lies between them, on the front of the tibia, and embedded in a considerable quantity of fatty connective tissue. The foot is a little flexed, the extensor pollicis tendon is drawn to the outer side by a small blunt hook, and the exposed artery is easily secured.

The nerve lies to the outer side, and the needle should be passed from the nerve. As the vessel is quite superficial, the venæ comites may be separated so as to make room for the needle (Fig. 46).

Comment.—The operation is without difficulty if one tendon be not mistaken for another. The nerve may lie in front of the artery. The two malleolar arteries—vessels about the size of the posterior auricular—come off just above the ankle-joint.

There are these objections to the operation in this situation: the upper band of the annular ligament is divided, and the synovial sheath of the tibialis anticus will almost certainly be opened. This is the only synovial sheath on the front of the limb at this level.

Collateral Circulation after Ligature of the Anterior Tibial Artery.

External Malleolar with Anterior Peroneal and Calcaneal of Posterior Peroneal.

Internal Malleolar with Internal Malleolar of Posterior Tibial.

Dorsalis Pedis and its Branches	with	Internal Plantar. External Plantar. Anterior Peroneal. Calcaneal of Posterior Peroneal.

Muscular branches from anterior and posterior tibial which anastomose after piercing the interosseous membrane.

Varieties of the Anterior Tibial Artery:

1. The vessel may be wanting, its place being supplied by perforating branches from the posterior tibial.
2. It may incline outwards towards the fibula at the lower part of the leg, and then return to its ordinary position on the dorsum of the foot.

3. It may become superficial about the middle of the leg, and run the rest of its course covered only by the fascia and the skin.

THE POSTERIOR TIBIAL ARTERY (III.).

Anatomy.—The vessel lies between the superficial and the deep muscles of the calf, and is closely bound to those of the latter group by the deep fascia which covers them. At its origin at the lower border of the popliteus muscle, the artery is opposite the interval between the tibia and fibula. It arises on a level with the lower part of the tubercle of the tibia, and about two inches below the knee-joint. It divides at the lower border of the inner annular ligament, on a level with a line drawn from the tip of the malleolus to the centre of the convexity of the heel.

Fig. 47.—LINE OF THE POPLITEAL, POSTERIOR TIBIAL AND PERONEAL ARTERIES (RIGHT LIMB).

The upper part of the artery is very deeply placed beneath the gastrocnemius and soleus muscles. In the lower third of the leg the vessel is superficial, being covered only by the skin and the fascia. It lies successively on the tibialis posticus, the flexor longus digitorum, the tibia and the ankle-joint. There are two venæ comites, which lie one on either side of the artery. The posterior tibial nerve lies at first on the inner side of the artery. It crosses the vessel about one inch below the lower border of the popliteus muscle, and runs for the rest of its course to the outer side of the artery.

Line of the Artery.—A line drawn from the centre of the ham to a point midway between the inner malleolus and the heel will correspond to about the lower half of the artery. The upper half forms a slight curve inward from this line (Fig. 47).

Indications.—The artery may be tied in the leg or behind the ankle. It is usually secured for wound. The vessel may

be ligatured at its lower end in some cases of wound of the sole.

In some punctured wounds of the thick part of the calf doubts may exist as to which of the deep vessels is wounded. In such a case elevation of the limb, with pressure, followed possibly by the distal ligature, may be a better mode of treatment than an extensive dissection of a muscular limb in search of the bleeding point. Laceration of this artery associated with fracture of the bone has been successfully treated by the distal ligature in Hunter's canal.

Aneurysm is more common in the posterior than in the anterior tibial. Kinloch had tabulated twenty-two examples of spontaneous aneurysm in 1882. The tumour usually occupies the upper half of the leg. When Esmarch's bandage, acute flexion of the knee, and compression of the femoral have failed, the artery has been secured with success above the aneurysm, provided the latter has been placed low enough down.

Fig. 48.—LIGATURE OF THE RIGHT POSTERIOR TIBIAL ARTERY.

1. **Ligature behind the Malleolus.**

Position.—The patient lies on the back. The knee is flexed, and the leg lies upon its outer side. The foot lies upon the table also on its outer side, and is secured in that posture by an assistant. The surgeon stands to the outer side of the limb in either instance (right or left limb).

Operation.—A curved incision, two inches in length, is made about half an inch behind and parallel with the margin of the inner malleolus (Fig. 48). The knife is directed towards the tibia. The internal annular ligament is exposed, and divided over the artery. The vessels and the nerve lie in a gap between the tendons that

can be appreciated by the touch. The artery having been exposed and separated from the veins, the needle is passed from without inwards.

Comment.—If the veins are very closely applied about the artery, they may be included in the ligature. In case of high division of the trunk, two vessels will appear, and both will require to be secured. Care must be taken not to open the sheaths of the adjacent tendons. The first canal in the annular ligament (that nearest to the malleolus) contains the tibialis posticus tendon; the second contains the tendon of the flexor longus digitorum. Each of these canals has a separate synovial lining. Then follows a space wider than that for either of the two named canals, in which are lodged the vessels and nerve. A fourth canal on the astragalus, lined also by a synovial membrane, transmits the flexor longus pollicis tendon.

Fig. 49.—LIGATURE OF RIGHT POSTERIOR TIBIAL ARTERY (LOWER THIRD).

A, Fascia of leg (internal annular ligament); B, Flexor longus digitorum and tendon; C, Tendo Achillis; *a*, Posterior tibial artery; *b*, Posterior tibial vein; 1, Posterior tibial nerve.

2. **Ligature at the Lower Third of the Leg.**

Operation.—The position is the same as in the previous operation. An incision, two inches in length, is made along the line of the artery midway between the margin of the tendo Achillis and the inner edge of the tibia (Fig. 48). The superficial and deep fasciæ are divided, together with the upper part of the inner annular ligament. The artery is found lying on the flexor longus digitorum muscle, with the nerve to its outer side. The needle is passed from the nerve. The venæ comites will have to be included if they cannot be readily separated from the artery (Fig. 49).

Comment.—The flexor longus digitorum contains fleshy fibres until the malleolus is reached. The vessel lies upon the fleshy part, and to the outer side of the tendon.

The communicating branch between the posterior tibial

and peroneal arteries arises an inch above the ankle-joint. The ligature will be placed above this branch.

3. **Ligature in the Middle of the Calf.**

Operation.—The position is the same as in the preceding operations. The calf of the leg rests upon the table on its outer side, and the surgeon leans over the limb. The incision is made from above downwards on the right side, and from

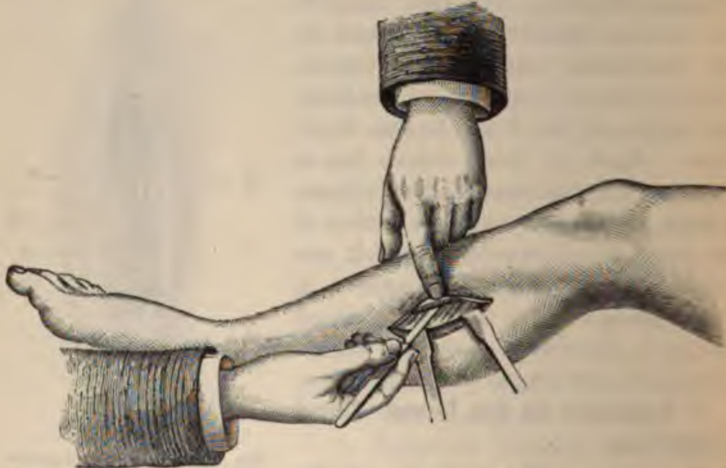

Fig. 50.—THE MODE OF DIVIDING THE SOLEUS MUSCLE IN LIGATURE OF THE RIGHT POSTERIOR TIBIAL ARTERY IN THE MIDDLE OF THE CALF. (*After Farabeuf.*)

below up on the left. The assistant, armed with retractors, stands on the opposite side of the table.

An incision, four inches in length, is made in the middle third of the leg, parallel to the inner margin of the tibia and three-quarters of an inch behind that crest of bone (Fig. 48). The skin having been divided, care must be taken not to wound the internal saphenous vein, which should be drawn aside. The deep fascia—the fibres of which are all transverse—is exposed and divided. In a muscular subject the margin of the gastrocnemius may be seen.

The soleus is now exposed, and must be divided through the length of the incision. The aponeurosis of the muscle is cut through, together with the fleshy fibres attached to it. In making this section the knife should be kept perpendicular

to the surface of the muscle. Its edge will therefore be directed towards the tibia, and its blade—in the position in which the limb is held—will be nearly horizontal (Fig. 50). When the muscle has been divided, the outer part must be drawn well outwards by a broad retractor or retractors held by an assistant. The deep fascia that covers in the vessels and the deep muscles of the leg is now exposed. If the finger be introduced the vessel can be felt. It must be remembered that the artery lies near the outer border of the tibia. When the fascia has been divided (it is usually very thin) the fleshy fibres of the flexor longus digitorum are exposed. These fibres all run obliquely downwards. By following the surface of the muscle the vessels are reached. The veins are very conspicuous, and may hide the artery. The nerve lies to the outer side, and the needle should be passed from the nerve. It is practically impossible to separate the venæ comites from the vessel.

Comment.—This operation requires a good light, and may be most conveniently done with the aid of a small electric lamp.

The tissues must be carefully retracted, and all the soft parts drawn outwards. In using the retractors roughly, some fibres of the flexor longus digitorum may be torn up and made to hide the artery. This may readily occur in the cadaver. If in dividing the soleus the knife be not kept towards the tibia, a too extensive division of muscle results, and the wound is unnecessarily deepened.

If the section of this muscle is made too close to the tibia, it is very easy to get the retractor beneath the flexor digitorum, and the surgeon dissecting on beneath that muscle may find himself at the interosseous membrane. The soleus at the point of section is—in a fairly developed subject—somewhat thicker than the little finger. The lateral tendinous intersection in the substance of the muscle may be encountered and divided. In identifying muscle it should be remembered that the fibres of the soleus in this situation are attached only along the narrow line formed by the inner margin of the tibia. The surgeon should not lose sight of the fact that the part for which he is aiming is in a line with the outer margin of the tibia.

Collateral Circulation after Ligature of the Posterior Tibial Artery:

Peroneal	with	Posterior Tibial by communicating Branch and by Muscular Branches.
External Calcaneal of Peroneal	with	Internal Calcaneal of External Plantar.
External Malleolar	with	External Plantar.
Internal Malleolar of Anterior Tibial	with	Internal Malleolar of Posterior Tibial.
Dorsalis Pedis and its Branches	with	Internal and External Plantar.

Varieties of the Posterior Tibial Artery:

1. The artery may be very small at its commencement, and be reinforced lower down by transverse branches from the peroneal.
2. It may be wanting and be replaced by the peroneal.
3. It may be covered in the lower third of the leg by muscle which may represent an accessory long flexor of the toes or a slip of the soleus (Quain).

THE PERONEAL ARTERY (III.).

Anatomy.—This vessel is the same size as the anterior tibial. It arises about an inch below the lower border of the popliteus muscle. It first inclines outwards towards the fibula, resting on the tibialis posticus and covered by the soleus and the deep fascia. It then descends vertically along the inner border of the bone, under cover of the flexor longus pollicis (Fig. 47). A little above the middle of the fibula it enters a fibrous canal between the origins of the flexor longus pollicis and the tibialis posticus. At the lower third of the leg the vessel divides into anterior and posterior peroneal. Two venæ comites follow the artery. The vessel rapidly diminishes in size, and below the middle of the leg is often of quite insignificant dimensions.

Indications.—The ligature of the vessel scarcely belongs to practical surgery. It may be—and has been—secured for wound, and is in such a case reached through the wound already made.

The artery may in rare cases be of large size, and found to reinforce a small posterior tibial.

Ligature about the Middle of the Leg.

Operation.—The patient lies upon the sound side, almost upon the abdomen. The knee is a little flexed, and the leg lies upon its antero-internal surface, being held firmly upon the table by an assistant.

An incision, three and a half inches in length, is made parallel with and immediately behind the outer border of the fibula. The centre of the incision corresponds to the middle of the leg. The fascia having been divided, the soleus muscle is exposed. At the site of the operation the muscle will have ceased to arise from the fibula. (It takes origin from the upper third only of that bone.) The muscle must be drawn inwards, and any portion of its attachment to the fibula in the upper part of the wound is divided if necessary. The fibula will now be distinctly exposed. The fibres of the flexor longus pollicis are then to be severed close to the fibula, until the membranous wall of the canal containing the vessel is exposed. This is carefully laid open, and the artery is found lying against the inner margin of the bone.

The needle may be most conveniently passed from the outer side, and will probably take up also the venæ comites.

The muscular tissue must be well held aside by retractors, as the wound is deep.

THE POPLITEAL ARTERY (I.–II.).

Anatomy.—The vessel extends from the opening in the adductor magnus to the lower border of the popliteus muscle, passing through the centre of the popliteal space. From its commencement to a point behind the middle of the knee-joint, the artery inclines from within outwards; beyond this point it descends vertically (Fig. 47). The artery is deeply placed. Its upper end is covered by the semi-membranosus muscle, its lower end by the gastrocnemius. Between these points it lies deeply in the popliteal space. The popliteal vein lies close to the artery. It is placed at first to the outer side, and a little behind the artery; it then gradually crosses over that vessel, and ultimately gains its inner side. This vein is remarkably substantial, and has walls so thick and dense that in section they look not unlike the tunics of an artery. It is,

moreover, very closely adherent to the artery. It may be double along the lower part of its course.

The internal popliteal nerve is at first to the outer side of the artery, and superficial to it. It then crosses gradually over the vessels, and lies behind and to the inner side of them, below the joint. The nerve is throughout separated from the artery by the vein. In the centre of the ham the nerve and vein lie exactly over the artery.

The crease in the skin which crosses the popliteal space transversely is some way above the line of the knee-joint.

The guide to the upper part of the artery is the outer border of the semi-membranosus. The popliteal ends on a level with the lower part of the tubercle of the tibia.

Indications.—The conditions which would justify ligature of the popliteal artery are exceedingly few. If a ligature be required in dealing with aneurysm of the leg, the femoral would be secured. So many and so exceptional difficulties attend the operation of Antyllus in cases of popliteal aneurysm that most surgeons prefer to deal with such cases by amputation when other means have failed.

The popliteal may be ligatured in some cases of wound, *e.g.*, a wound received from the chisel in performing osteotomy. MacCormac considers it may be ligatured "possibly for a small recent traumatic aneurysm."

The artery may be secured at its upper or at its lower part. In the middle of its course it would scarcely be exposed surgically. The vessel is here very deeply placed, is surrounded by much fat, is covered by the vein and the nerve, is giving off numerous branches, and is very close to the synovial membrane of the knee-joint.

Even as a dissecting-room operation, the ligature of the artery at its middle third has little to recommend it.

1. Ligature of the Lower Part of the Artery.

Operation.—The patient is so rolled over as to rest upon the shoulder and one side of the chest, and is indeed made to lie as nearly prone as the circumstances attending the administration of an anæsthetic will permit. The limb is fully extended. The surgeon will stand to the outer side of the left limb and to the inner side of the right. The chief assistant

is placed opposite to him. In the case of either extremity the incision is made from above downwards.

A vertical incision—from three to three and a half inches in length—is made over the back of the limb, commencing opposite to the centre of the popliteal space (*i.e.*, the level of the knee-joint), and extending downwards over the interval between the two heads of the gastrocnemius muscle.

The skin and superficial fascia having been divided, care must be taken not to damage the short saphenous vein and nerve. These structures will appear at the outer part of the wound, and should be drawn outwards. The deeper fascia is divided in the same vertical line.

The heads of the gastrocnemius muscle are now exposed, and the surgeon follows the interval between them. On each side of this gap a sural artery will be found, accompanied by the nerve to the corresponding head of the muscle.

Deep in the interval itself the large nerve to the soleus muscle (from the internal popliteal) will probably be met with, and must be drawn aside. It usually lies directly in the line of the operation.

Fig. 51.—LIGATURE OF RIGHT POPLITEAL (LOWER PART).

A, Fascia; B, Gastrocnemius; *a*, Popliteal artery; *b*, Popliteal vein; *c*, External saphenous vein; 1, Internal popliteal nerve; 2, Muscular branches; 3, External saphenous nerve.

Following the short saphenous vein, the surgeon is guided to the popliteal vessels. This part of the operation is rendered easier by flexing the knee-joint a little so as to relax the gastrocnemius. The internal popliteal nerve is first encountered, then the vein and the artery. The two first-named structures are drawn to the inner side. The artery is cleared, and the needle is passed from the inner side (Fig. 51).

2. **Ligature of the Upper Part of the Artery.**—This

operation—known as Jobert's operation for the ligature of the popliteal artery (*Nouvelle Bibliothèque Méd.*, Feb., 1827)—is carried out in the thigh. The vessel is secured close to the inner side of the femur, and is reached between the semi-membranosus muscle and the tendon of the adductor magnus.

Operation.—The patient lies upon the back, with the hip a little flexed and the thigh fully abducted and rotated outwards. The knee-joint is bent at a right angle, and the knee and leg are thus made to lie upon the outer side.

The surgeon stands to the outer side of the extremity in either case. The incision on the right side is made from above downwards, and on the left from below upwards. The chief assistant faces the operator.

The incision is three inches in length, is commenced at the junction of the middle with the lower thirds of the thigh, and is parallel with and just posterior to the tendon of the adductor magnus. The position of this tendon should have been well defined (Fig. 52).

After the skin has been divided, there will probably be found in the subcutaneous fat the anterior division of the internal cutaneous nerve, which lies usually in the direct line of the operation. It should be drawn aside.

The anterior edge of the sartorius muscle is next exposed, and the whole muscle must be displaced backwards.

Upon this muscle at this point will lie the internal saphenous vein. The vessel may possibly be exposed, in which case it is drawn backwards with the sartorius.

The trunk of the internal saphenous nerve is not encountered. It lies beneath the sartorius.

The deep fascia having been well divided, the tendon of the adductor magnus is sought for, and is drawn forwards with a blunt hook. The semi-membranosus muscle is next exposed, and is drawn backwards with a retractor. The operator now seeks for the artery in the interval between the two structures. The vessel will be surrounded by much connective tissue, and is lying close to the bone. The internal popliteal nerve is here at some distance from the vessel, and will not be seen. The vein also is not necessarily exposed. It lies posterior to the artery, and to its outer side. Indeed, as approached from this

point the artery is the most superficial of the three structures named.

When the vessel has been properly exposed, the needle may be passed from below upwards.

An aneurysm needle with a large lateral curve will be found the most convenient.

In performing this operation care must be taken not to wound the deep branch of the anastomotica magna artery, which runs along the anterior surface of the adductor magnus tendon.

Collateral Circulation after Ligature of the Popliteal Artery.

The inferior articular arteries, the anterior tibial recurrent (with possibly the posterior tibial recurrent and superior fibular branches of the anterior tibial), *below* the ligature communicate with the superior articular arteries, the anastomotica magna and external circumflex arteries *above* the ligature.

Muscular branches will also take part in establishing the new circulation.

Varieties of the Popliteal Artery.—This artery is very seldom found to deviate from the normal condition. The only variety which is at all common is the high division of the vessel into its terminal branches. Such division may take place opposite the knee-joint or even behind the intercondyloid fossa of the femur.

THE FEMORAL ARTERY.

Anatomy.—The diameter of the common femoral is from 9 to 10 m.m., the superficial femoral is the size of the carotid artery and the profunda of the brachial.

At the groin the artery is in front of the summit of the head of the femur. At its lower end it lies close to the inner surface of the shaft of the femur. Between these points it is placed at some little distance from the bone.

The vessel lies, in order from above downwards, upon the psoas, pectineus, adductor brevis, adductor longus, and the tendon of the adductor magnus.

The femoral lies at first in Scarpa's triangle, where it is superficial. The apex of this triangle is from three to three and a half inches below Poupart's ligament.

The vessel then enters Hunter's canal, which occupies the middle third of the limb.

In this canal are the artery and vein, the internal saphenous nerve, and the superficial part of the anastomotica magna artery.

The profunda femoris arises one inch and a half below Poupart's ligament, and the two circumflex arteries some two inches below that structure.

At the groin the femoral vein is upon the same plane as the artery, and to its inner side. At the apex of Scarpa's triangle the vein is behind the artery. In Hunter's canal it lies

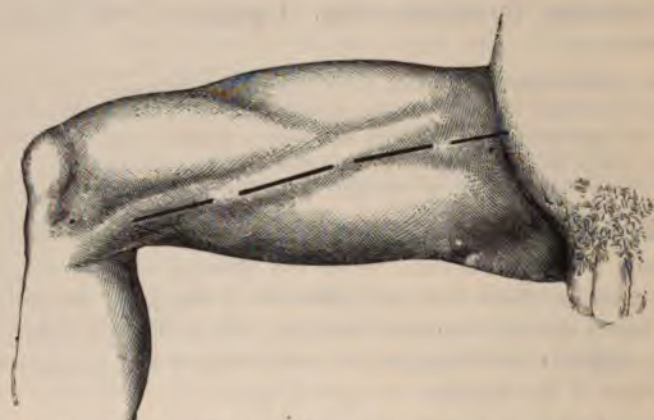

Fig. 52.—LIGATURE OF THE RIGHT COMMON FEMORAL AT THE BASE OF SCARPA'S TRIANGLE; OF THE FEMORAL AT THE APEX OF SCARPA'S TRIANGLE AND IN HUNTER'S CANAL, AND OF THE UPPER PART OF THE POPLITEAL.

behind, and a little to the outer side. The vein is throughout very close to the artery.

At the apex of Scarpa's triangle both the femoral and the profunda veins separate the two corresponding arteries; the order from before backwards being—the femoral artery, the femoral vein, the profunda vein, the profunda artery.

The anterior crural nerve lies well to the outer side of the artery at the groin. The internal cutaneous nerve crosses the vessel at the upper edge of the sartorius. The internal saphenous nerve comes in front of the artery, just above the middle of the thigh, and lies in front, and a little to the outer side of it, in Hunter's canal.

The course of the long saphenous vein may be roughly

represented by a line drawn from a point about three-quarters of an inch to the inner side of the line of the femoral artery at the groin, to the posterior border of the sartorius muscle, at the level of the condyle of the femur.

Line of the Artery.—The hip being a little flexed and the thigh abducted and rotated outwards, a line is drawn from a point midway between the anterior superior spine of the ilium and the symphysis pubis, to the tuberosity of the internal condyle (Fig. 52). The centre of Poupart's ligament is entirely to the outer side of the line of the vessels.

Indications.—The superficial femoral may be ligatured in Hunter's canal or at the apex of Scarpa's triangle. The common femoral may be ligatured at the base of that triangle.

The only one of these three operations which is performed with any degree of frequency is the ligature at the apex of Scarpa's triangle. This is called the "place of election," and in any case in which "ligature of the femoral" is advised or is mentioned, it is assumed that the vessel is secured at this point.

A ligature may be applied here in certain cases of popliteal and lower femoral aneurysm which have resisted simpler treatment, and in certain cases of wound.

The femoral has been tied at this point also for the relief of elephantiasis Arabum.

A ligature is very rarely indeed applied to the common femoral. Great risks attend the procedure. The risk of gangrene is considerable, as is also that of secondary hæmorrhage. The operation has proved to be more dangerous when the vessel is secured between the deep epigastric and profunda arteries than when it is ligatured either above or below those branches.

The numerous small vessels which arise from the common femoral, the proximity of the profunda, and the occasional high origin of that vessel or of one of the circumflex arteries, render a sound occlusion of the main artery a matter of uncertainty. In most of the circumstances in which a ligature of the common femoral might be suggested, the securing of the external iliac artery is the better procedure in actual practice.

The common femoral is secured as a preliminary measure

in some amputations at the hip joint, and in certain cases of wound.

The ligature in Hunter's canal has been employed in cases of wound, in some exceptional examples of aneurysm, and in bleeding from the stump after amputation through the lower part of the thigh. John Hunter was the first surgeon to apply a ligature to this part of the artery for popliteal aneurysm. The operation was performed in 1785.

Position.—The patient lies upon the back, with the hip a little flexed, with the thigh abducted and rotated outwards, with the knee bent and the leg resting upon its external surface.

The surgeon stands to the outer side of the limb in either case, and the chief assistant is placed opposite to him. The incision—in the case of the right thigh—is made from above downwards, and in the case of the left from below upwards.

Ligature of the Superficial Femoral in Hunter's Canal

Operation.—The limb having been placed as already indicated, an incision three and a quarter inches in length is made along the line of the artery in the middle third of the thigh (Fig. 52).

In the layer of subcutaneous tissue the anterior division of the internal cutaneous nerve will probably be met with, and to the inner side of it the long saphenous vein. This vessel must be drawn inwards.

The fasica lata is now divided in the line of the original wound, and the sartorius is exposed. This muscle must be clearly identified. Its fibres run downwards and inwards.

The anterior or outer edge of the muscle having been exposed, the whole structure is drawn inwards with a suitable retractor.

The site of Hunter's canal, lying between the adductor magnus and the vastus internus, can now be well defined, especially if the fibres of the great adductor and the lower border of the adductor longus are made prominent by fully abducting the thigh.

When any fatty tissue which may obscure the part has been cleared away, the fascia which forms the roof of Hunter's canal is rendered distinct. The fibres forming this fascia are arranged transversely.

At this point there may be exposed, at the outer side of the wound, the nerve to the vastus internus.

The canal is opened in the line of the original wound, and the artery exposed (Fig. 53).

The needle may be passed from either side.

In front and to the outer side of the vessel will be found the internal saphenous nerve, which is easily avoided.

Care must be taken that the vein be not damaged in passing the needle round the artery.

Comment.—The cut is apt to be made too far outwards, in which case the vastus internus is exposed instead of the sartorius, and the one muscle may be mistaken for the other. Their fibres, however, run in opposite directions, those of the vastus downwards and outwards, those of the sartorius downwards and inwards.

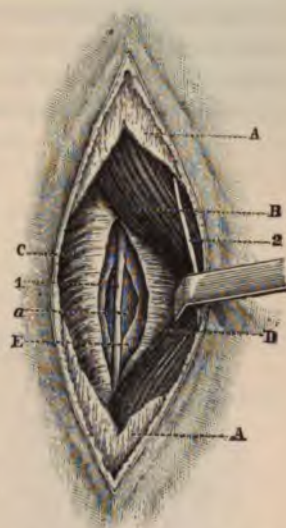

Fig. 53.—LIGATURE OF RIGHT FEMORAL ARTERY IN HUNTER'S CANAL.

A, Fascia lata; B, Sartorius; C, Vastus internus; D, Fascia closing in Hunter's canal; E, Sheath of artery; *a*, Femoral artery; 1, Long saphenous nerve; 2, Anterior branch of internal cutaneous nerve.

The incision may be made too low down, and the popliteal artery be reached.

In making the skin wound carelessly the internal saphenous vein has been cut into.

The whitish tendon of the adductor magnus has been mistaken for the artery in the dead subject.

Farabeuf recommends that as soon as the sartoriu muscle has been drawn aside, the thigh should be wel abducted and rotated out, so as to bring into prominence a tendinous cord—*la corde qui vibre*—which is derived from the lower fibres of the adductor longus, and is passing to the general adductor insertion. This cord helps to define the canal, and the incision is made first to its outer side.

2. **Ligature of the Superficial Femoral at the Apex of Scarpa's Triangle.**

Operation.—The limb is placed in the position already indicated, and the line of the artery is marked out.

An incision three inches in length is made along this line as it crosses the apex of Scarpa's triangle. The centre of the wound should correspond to the apex, and the incision, therefore, will reach to within one and a half or two inches of Poupart's ligament (Fig. 52).

A large tributary of the internal saphenous vein will usually be exposed, and if it cannot be drawn easily aside it should be divided between two ligatures.

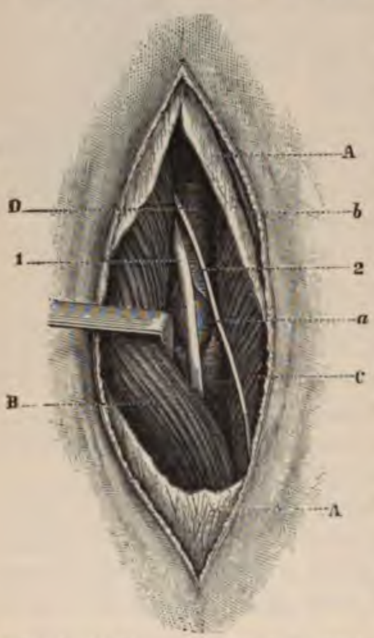

Fig. 54.—LIGATURE OF RIGHT FEMORAL ARTERY AT APEX OF SCARPA'S TRIANGLE.

A, Fascia lata; B, Sartorius; C, Adductor longus; D, Sheath of artery; *a*, Femoral artery; *b*, Tributary to internal saphenous vein; 1, Long saphenous nerve; 2, Internal cutaneous nerve.

The fascia lata having been divided in the original line, the sartorius is exposed at the outer part and inferior end of the wound, its fibres running downwards and inwards.

Its inner border should be well isolated, and the whole muscle is then drawn outwards.

The operator now feels for the groove of the artery. In front of the vessel will be found branches of the internal cutaneous nerve, and deeper and to its outer side are the long saphenous nerve, and, possibly, the nerve to the vastus internus (Fig. 54).

The sheath of the vessel should be well opened, and the needle passed from the inner side.

Comment.—Scarpa's triangle is much smaller than would appear to be the case when the dissected region is inspected. There may be no more than two inches of the artery left uncovered by the sartorius muscle. An unusually

broad sartorius adds a little to the difficulty of the operation.

In order to reach the edge of the sartorius muscle easily, the cut is often made too much to the inner side, with the result that the great saphenous vein is cut into. On the other hand, if the thigh be not placed in proper position, the incision is apt to fall too much to the outer side.

The special danger of the operation consists in the wounding of the vein in passing the needle. The greatest care must be taken to open the sheath of the artery well, and to keep the point of the needle close to the arterial wall.

An aneurysm needle, curved laterally, will usually be found the more convenient.

3. Ligature of the Common Femoral at the base of Scarpa's Triangle.

Operation. — The position of the surgeon and of the patient has been already indicated. An incision two inches in length is commenced a little above Poupart's ligament (*i.e.*, on the abdomen), and is carried downwards parallel with the line of the artery (Fig. 52).

In dividing the layer of fatty tissue which covers the fascia lata, care must be taken not to injure any of the lymphatic glands of the region, and to avoid the superficial veins, notably the superficial epigastric and superficial circumflex iliac. The cribriform fascia is now divided in the original line, and especial care must be taken not to wound the superficial arteries, the two which usually come nearest to the incision being the superior external pudic and the superficial epigastric.

Fig. 55. — LIGATURE OF RIGHT COMMON FEMORAL AT BASE OF SCARPA'S TRIANGLE.

A, Line of Poupart's ligament; B, Superficial fascia; C, Fascia lata; D, Sheath; *a*, Femoral art.; *b*, Femoral vein; *c*, Int. saphenous vein; 1, Genito-crural nerve.

The crural branch of the genito-crural nerve lies upon the sheath of the artery, but upon the outer side of the vessel.

N 2

The sheath being clearly exposed and carefully opened, the needle is passed from the inner side (Fig. 55).

Comment.—By starting from the level of the centre of Poupart's ligament, the incision is placed to the outer side of the line of the vessels, and the vein is thus more certainly avoided. When the vein is at all distended, it is apt to overlap the artery.

Collateral Circulation after Ligature of the Femoral Artery.

(a) *After Ligature of the Common Femoral:*

Above.		*Below.*
Internal pudic	with	Pudic of femoral.
Gluteal	with	External circumflex, internal circumflex, and first perforating.
Circumflex iliac	with	External circumflex.
Obturator	with	Internal circumflex.
Sciatic	with	Superior perforating and internal circumflex.
Comes nervi ischiadici	with	Perforating.

(b) *After Ligature of the Superficial Femoral:*

Above.		*Below.*
External circumflex	with	Lower muscular branches of femoral, anastomotica magna, and superior articular branches of popliteal.
Perforating arteries and termination of profunda.	with	Muscular branches of the femoral and popliteal and the superior articular arteries.

A communication is effected along the back of the thigh, between the sciatic artery, the terminal branches of the internal circumflex, the perforating arteries, and the branches of the popliteal. "In several instances in which the condition of the vessels has been examined after ligature of the femoral (or external iliac) artery, the comes nervi ischiadici has been found much enlarged, forming, with anastomotic branches from the perforating arteries, a vessel which accompanies the great sciatic nerve, and ends below in the popliteal artery, or one of its branches." (*Quain.*)

Varieties of the Femoral Artery.—1. The femoral may divide below the origin of the profunda into two vessels, which reunite again at a variable distance above the opening in the adductor magnus to form a single popliteal artery.

2. A vas aberrans may leave the external iliac artery, and running by the inner side of the common femoral artery, may join the superficial femoral about the apex of Scarpa's triangle.

3. The main artery of the limb may be found wholly at the back of the thigh, and be derived from a greatly enlarged sciatic artery.

4. The profunda may arise from the inner or from the posterior side of the main vessel, and may take origin less than one inch or more than two inches below Poupart's ligament.

5. The circumflex arteries may arise in whole or in part from the femoral. This especially applies to the internal circumflex.

6. The femoral may give off the deep epigastric, the circumflex iliac, or the great saphenous artery. The last named vessel arises above or below the origin of the profunda, and passing along Hunter's canal, becomes superficial at the inner side of the knee, and follows the internal saphenous vein to the ankle.

CHAPTER V.

Ligature of the Iliac Arteries, and of the Abdominal Aorta.

THE EXTERNAL ILIAC ARTERY.

Anatomy.—This vessel extends from the bifurcation of the common iliac, at the lumbo-sacral articulation, to Poupart's ligament, measures from three and a half to four inches in length, and has a diameter of from 9 to 10 m.m.

The artery lies upon the iliac fascia, with which it is connected by a thin sheath derived from the subperitoneal tissue. It runs along the inner margin of the psoas muscle, and at Poupart's ligament is placed actually upon that muscle.

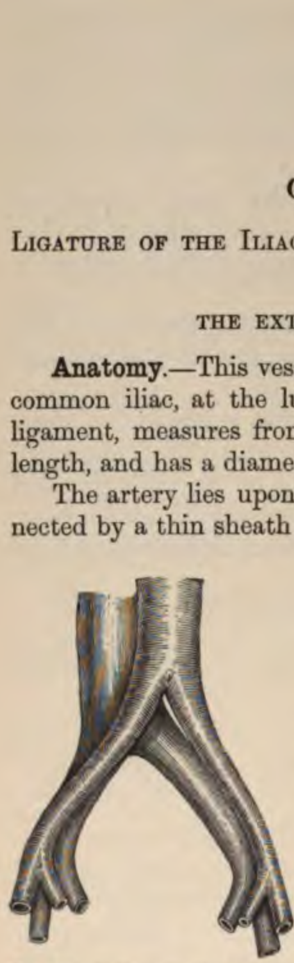

Fig. 56.—Relation of veins to the common iliac arteries.

It is covered by peritoneum. The sigmoid flexure crosses it on the left side, and the terminal part of the ileum on the right. The ureter passes over the vessel at the point of bifurcation of the common iliac.

About three-quarters of an inch above Poupart's ligament the artery is crossed by the circumflex iliac vein (represented at this point by a single trunk).

Passing over the lower part of the artery are the spermatic vessels, and the vas deferens, which latter curves round the deep epigastric artery.

The genital branch of the genito-crural nerve lies upon the artery at its outer side. Some lymphatic glands and not a few lymphatic vessels lie upon or about the vessel.

The deep epigastric artery arises about one-fourth of an inch above Poupart's ligament, and runs between the trans-

versalis fascia and the peritoneum, in the direction of the umbilicus. The deep circumflex iliac artery comes off usually below the epigastric, and runs outwards behind Poupart's ligament, and rests upon the iliacus muscle.

The external iliac vein is at first behind the artery, and a little to the inner side. It ultimately is found upon the same plane as the artery, and entirely to the inner side (Fig. 56).

The internal abdominal ring is situated about half an inch above Poupart's ligament, opposite a point midway between the anterior superior spine of the ilium and the symphysis pubis.

Line of the Artery.—A line drawn on the surface of the abdomen from a spot about a finger's breadth to the left of and below the navel, to a point midway between the anterior superior iliac spine and the symphysis pubis. The upper third of this line represents the common iliac, the lower two-thirds the external iliac (Fig. 57).

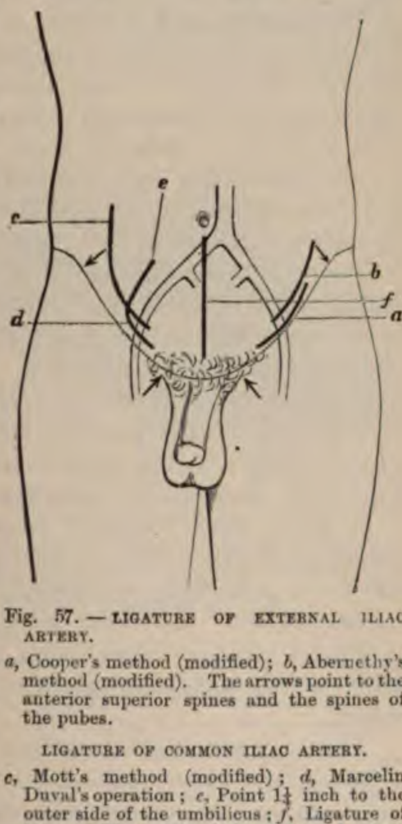

Fig. 57. — LIGATURE OF EXTERNAL ILIAC ARTERY.

a, Cooper's method (modified); *b*, Abernethy's method (modified). The arrows point to the anterior superior spines and the spines of the pubes.

LIGATURE OF COMMON ILIAC ARTERY.

c, Mott's method (modified); *d*, Marcelin Duval's operation; *e*, Point 1¼ inch to the outer side of the umbilicus; *f*, Ligature of internal iliac artery (intraperitoneal operation).

Indications.—The artery has been secured in cases of wounds and of secondary hæmorrhage, and for the treatment of aneurysms in the upper part of the thigh.

It has been ligatured also to arrest the progress of malignant growths, and to modify the condition of the limb in elephantiasis Arabum.

So far as the mortality of the actual operation is concerned, the procedure may be regarded as a successful one, 169 recorded cases having given in all but 61 deaths (Lidell). The vessel was ligatured for the first time in 1796 by Mr. Abernethy for inguinal aneurysm. His first two cases died, but the third and fourth recovered. (*Medical and Physical Journal*, 1802, page 97; and "Surgical Works," vol. i.)

Preparation and Position of the Patient.—The bowels should have been well evacuated, and if there be much flatulent distension of the abdomen, the operation, if not urgent, might be postponed until such complication has been dealt with. The pubic hair should be shaved.

The patient lies upon the back, with the thighs extended and close together. The head and shoulders should be raised in order to relax the abdominal parietes a little.

The surgeon stands to the outer side of the body in dealing with either artery, and cuts from above downwards on the right side, and from below upwards on the left. His face is towards the patient's face. In slender subjects the left artery might be quite conveniently tied, as the operator stands to the right of the patient's body. The chief assistant is placed opposite to the surgeon, and to him is entrusted the responsible office of using the retractor.

A good broad retractor is needed, together with long dissecting forceps, and an aneurysm needle with a lateral curve. A good light is essential. A reflector will be found convenient, but the most substantial aid is afforded by a portable electric lamp—such as Trouvé's. With such a lamp as this the main difficulties of the operation are removed.

There are two original methods of exposing the artery, both of which have been modified beyond recognition, and which are known as Cooper's operation and Abernethy's method.

1. **Sir Astley Cooper's Operation.**

The Original Procedure.—"The patient being placed in the recumbent posture, on a table of convenient height, the incision is to be begun within an inch of the anterior superior spinous process of the ilium, and is extended downwards in a semicircular direction to the upper edge of Poupart's ligament. This incision exposes the tendon of the

external oblique muscle: in the same direction the above tendon is to be cut through, and the lower edges of the internal oblique and transversalis abdominis muscles are exposed; the centre of these muscles is then to be raised from Poupart's ligament. The opening by which the spermatic cord quits the abdomen is thus exposed, and the finger passed through this space is directly applied upon the iliac artery, above the origin of the epigastric and circumflexa ilii arteries. The iliac artery is placed upon the outer side of the vein; the next step in the operation consists in gently separating the vein from the artery by the extremity of a director, or by the end of the finger. The solid curved aneurysmal needle is then passed under the artery, and between it and the vein from without inwards, carrying a ligature; which being brought out at the wound, the needle is withdrawn, and the ligature is then tied around the artery as in the operation for popliteal aneurysm."

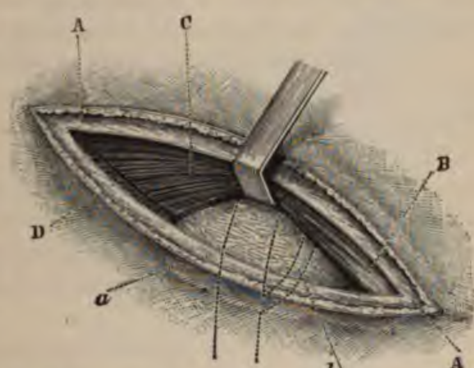

Fig. 58.—LIGATURE OF RIGHT EXTERNAL ILIAC ARTERY. *(Modified Cooper's method.)*

A, Aponeurosis of external oblique; B, Conjoined tendon; C, Internal oblique; D, Line of incision in int. oblique muscle; *a*, Position of ext. iliac artery; *b*, Position of deep epigastric artery.

The Modified Operation.—This operation has been modified in very many ways, and with such modifications various names have been associated. From the maze of these procedures the following may be selected as probably best representing the modern form of Cooper's operation.

The position of the patient has been indicated. An incision three and a half inches in length is made above Poupart's ligament. The cut is commenced about one inch and a quarter to the outer side of the spine of the os pubis, and is placed three-eighths of an inch above Poupart's ligament. For the inner two-thirds of its length it runs parallel with the

ligament, but for the outer one-third it curves a little upwards away from the ligament. (Fig. 57, *a.*)

The skin and subcutaneous tissues are cut through, and in the latter will be divided the superficial epigastric artery and vein.

The white, glistening aponeurosis of the external oblique muscle is now exposed, and is divided in the line of the skin incision. The knife follows very nearly the direction of its fibres. The parts being retracted, the surgeon now seeks for the external border of the conjoined tendon, which will be made out at the inner end of the wound.

The lower fibres of the internal oblique muscle are drawn upwards (Fig. 58), and are divided close to their attachment to Poupart's ligament. The extent of the division corresponds to the extent of muscle tissue exposed in the wound. (The internal oblique is attached to the outer half or two-thirds of Poupart's ligament, the transversalis to the outer third only.)

The fascia transversalis is now exposed, and is divided transversely over the artery, and as far on either side of it as is necessary.

At this stage of the operation care must be taken not to wound the deep epigastric artery, which passes—between the transversalis fascia and the peritoneum—across the wound area.

The external iliac artery can now be made out. The subperitoneal tissue about the vessels should be gently loosened, and the peritoneum then with the utmost care be peeled from the artery and vein, and be pushed upwards in the direction of the umbilicus (Fig. 59).

The fingers alone should be employed in this process. Any form of director is unnecessary and dangerous.

The artery should be bared to such a height as to allow the ligature to be passed around it at a point one inch and a quarter above Poupart's ligament.

The peritoneum must be kept out of the way with the broad retractor while the artery is being exposed.

The loose subperitoneal tissue which forms a kind of sheath for the artery should be cautiously cleared away.

The needle is passed from within outwards.

After the ligature has been secured, the divided fibres of

the internal oblique may be united to Poupart's ligament, and the rent in the external oblique aponeurosis be closed by a few points of catgut suture.

No drainage-tube is required.

Comment.—The wound must be of sufficient length, and be carefully placed.

If it be made too low down, there is danger of dividing the circumflex iliac vessels; if made too high up, of cutting into the internal abdominal ring. If it be carried too far outwards, an unnecessary amount of muscular tissue is divided; and if too far inwards, the external ring and the structures of the cord may be placed in jeopardy.

The tissues must be cleanly divided. The transversalis fascia should be cut sufficiently high to avoid the circumflex iliac vein, but not at too great a height.

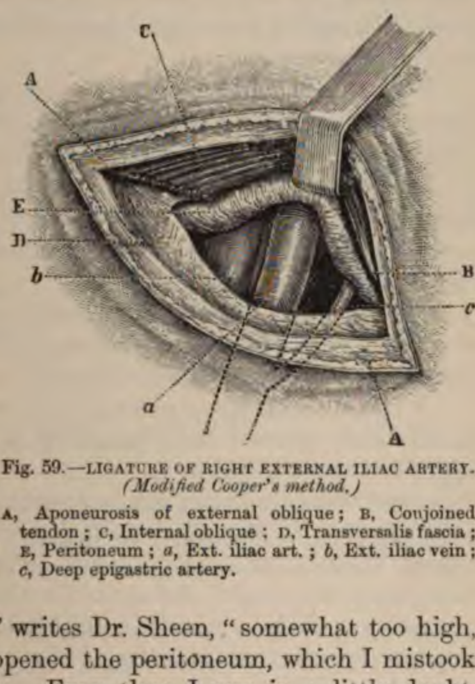

Fig. 59.—LIGATURE OF RIGHT EXTERNAL ILIAC ARTERY. *(Modified Cooper's method.)*

A, Aponeurosis of external oblique; B, Conjoined tendon; C, Internal oblique; D, Transversalis fascia; E, Peritoneum; *a*, Ext. iliac art.; *b*, Ext. iliac vein; *c*, Deep epigastric artery.

"I made the incision," writes Dr. Sheen, "somewhat too high, and, in consequence, opened the peritoneum, which I mistook for transversalis fascia. Even then I was in a little doubt, because some (omental) fat presented itself, which very much resembled the fat . . . seen around the vessel; but in pushing this up gently, a knuckle of bowel came into view, which settled the matter."

Care should be taken not to needlessly tear up the subperitoneal fatty tissue, and infinite care must be taken of the peritoneum. It should not be too extensively stripped up, and in clearing the artery with the finger it is possible to detach the vessel from the psoas muscle. The vein has been

damaged in passing the aneurysm needle, and the genito-crural nerve has been included in the ligature.

The peritoneum has been not infrequently opened. This has resulted sometimes from too high an incision, because the serous membrane becomes more and more intimately connected with the transversalis fascia the further the distance from Poupart's ligament. The peritoneal cavity has also been often opened up by the incautious use of the steel director (an instrument which should never be employed in this operation), and by a too free manipulation with the handle of the scalpel.

The artery should be secured at least one inch and a quarter above Poupart's ligament, in order that the ligature might be well clear of the large branches given off close to the ligament, and a space be allowed for the formation of the necessary clot.

The deep epigastric artery has been accidentally cut during the operation.

Without strict antiseptic precautions the operation carries with it the risks of peritonitis, and of diffuse inflammation of the iliac and pelvic connective tissue.

The position of the patient should be as described. It is inconvenient to relax the abdominal parietes by flexing the thighs as some suggest.

2. **Abernethy's Operation.**—Abernethy's original account is as follows:—"I first made an incision about three inches in length, through the integuments of the abdomen, in the direction of the artery, and thus laid bare the aponeurosis of the external oblique muscle, which I next divided from its connection with Poupart's ligament, in the direction of the external wound, for the extent of about two inches. The margin of the internal oblique and transversalis muscles being thus exposed, I introduced my finger beneath them for the protection of the peritoneum, and then divided them. Next, with my hand, I pushed the peritoneum and its contents upwards and inwards, and took hold of the external iliac artery with my finger and thumb. . . . It only now remained that I should pass a ligature round the artery and tie it." ("Surgical Works," vol. i., page 254.)

Abernethy later thought he had "disturbed the peritoneum

too much, and tied the artery higher than was necessary." He therefore modified the operation to the extent of making the incision lower down.

What was known as Abernethy's operation is described by South in 1847 ("Chelius' Surgery") in this manner. The incision was four inches in length, and was commenced one inch and a half above and to the inner side of the anterior superior iliac spine, and was carried down in the direction of the external iliac artery, to a point half an inch above Poupart's ligament. This incision is shown in Fig. 57, *b*. The muscles were divided in order, the peritoneum exposed and pushed back in the manner already described.

Comment and Comparison of the two Operations.—The comments made upon the previous operation apply, with obvious modifications, to the present method.

Abernethy's operation enables the artery to be ligatured higher up, and the incision is away from the centre of the groin. This is a matter of consequence in dealing with a case of aneurysm involving the upper part of the femoral artery, and possibly encroaching upon Poupart's ligament.

The wound, moreover, is removed from the abdominal rings, and does not concern the deep epigastric artery.

Cooper's operation, however, must be regarded as the better of the two, and to claim that position upon the following grounds:—The operation is easier to perform. The peritoneum is dealt with at a spot where it is but little adherent. It is, in consequence, more readily displaced, and is less exposed to damage.

There is infinitely less division of the muscular structures of the abdominal parietes, the wound is simpler, and the disposition to ventral hernia is less.

The artery is exposed at a great depth in Abernethy's operation, and the wound is so placed that the passage of the aneurysm needle is attended with great difficulty, and with unusual risk of wounding the vein.

The exposure of the deep epigastric artery would appear to be no objection to the operation advised. It is easily avoided.

It has not been shown that any special evils have attended the making of the incision close to the openings of the inguinal canal.

Abernethy's operation can be recommended when the region of the centre of the groin is, for one reason or another, inaccessible, or unsuited for the site of a surgical incision, and also in a case in which it is considered desirable to ligature the vessel as high up as possible.

Collateral Circulation after Ligature of the External Iliac Artery:

Above.		*Below.*
Internal mammary, lumbar and lower intercostal	with	Deep epigastric.
Lumbar and ilio-lumbar	with	Deep circumflex iliac.
Obturator and sciatic	with	Internal circumflex.
Sciatic	with	Superior perforating.
Gluteal	with	External and internal circumflex, and first perforating.
Internal pudic	with	External pudic.

For the varieties of the artery see page 211.

THE COMMON ILIAC ARTERY.

Anatomy.—The common iliac artery is about two inches in length, and has a diameter of 11 to 12 m.m. The right vessel is a little longer and usually a little larger than the left. The aorta bifurcates opposite to the centre of the body of the fourth lumbar vertebra, and a little to the left of the middle line. This point corresponds to a spot about three-quarters of an inch below, and just to the left of the umbilicus, and is on a level with a line drawn transversely between the highest parts of the two iliac crests.

The common iliac bifurcates opposite to the lumbo-sacral articulation.

The vessel is covered by peritoneum, and has running over it many sympathetic nerve fibres on their way to the hypogastric plexus. The ureter runs athwart the vessel near its bifurcation.

The left vessel lies close to the bodies of the fourth and fifth lumbar vertebræ, and alongside of the psoas muscle. The artery on the right side is separated from the psoas and the vertebræ by the two common iliac veins.

The relation of the veins to the arteries is shown in Fig. 56. It will be seen that the vena cava and both common

iliac veins are in close connection with the right common artery.

The vessels tend to become tortuous in old age.

The Line of the Artery has already been given (page 199).

Indications.—There are very few circumstances under which ligature of this vessel may be considered justifiable.

It has been secured in cases of wound of the artery, and in hæmorrhage from the external or internal iliac, or from the branches of the latter trunk.

It has been ligatured for the relief of aneurysm of the external or internal iliac, and as a preliminary to the removal of large vascular growths.

The vessel was first tied in 1812 by Professor W. Gibson, of Philadelphia (*Amer. Med. and Surg. Recorder*, vol. iii., page 185), for gunshot wound of the artery. The peritoneal cavity was opened up. The patient died on the thirteenth day.

Dr. Mott, of New York (*Amer. Jour. of Med. Sciences*, vol. i., page 156), carried out the first extra-peritoneal operation in 1827, for aneurysm of the internal iliac artery. The patient did well. The mortality of the operation has been very high. Lidell reports only sixteen recoveries in sixty-eight recorded cases. The very great majority of these operations took place before the introduction of antiseptic surgery, and some of the patients died of causes which are no longer unpreventable.

The recent tendencies of abdominal surgery render it probable that in the future the artery will be reached by a simple incision into the peritoneal cavity through the anterior abdominal parietes. (*See* Ligature of the Internal Iliac Artery and page 211.)

1. **Ligature of the Artery through an Anterior Incision.**—The preparation and position of the patient are the same as have been already described in dealing with the external iliac artery (page 200).

In stripping off the peritoneum the patient should be turned a little upon the sound side, in order that the intestines may be carried away from the wound area.

The incision on the right side may be made from above downwards, and on the left from below upwards.

A good light is required. Broad spatulæ or retractors are needed, and the surgeon should have provided himself with

that form of aneurysm needle which practice of the operation upon the dead body has shown him to be the most convenient. A large, long needle with a lateral curve (*see* page 102 of Introduction) will probably be found the most convenient.

(a) *Mott's Operation.*—An incision from five to eight inches in length is commenced just outside the centre of Poupart's ligament, and one inch and a half above it.

It then curves upwards and outwards in the direction of the ribs, passing the crest of the ilium one inch and a half in front (*i.e.*, to the inner side) of the anterior superior spinous process. (*See* Fig. 57, *c.*)

The skin and subcutaneous tissues are divided, and the aponeurosis of the external oblique is exposed, together with —in the upper part of the incision—a portion of the muscle itself. Both aponeurosis and muscular fibres are divided in the line of the original incision. The internal oblique muscle is now reached, and is cut through in the same manner.

The transversalis muscle is in turn exposed, and its fibres are severed from one end of the wound to the other.

Between the two last-named muscles will be met the ilio-hypogastric, ilio-inguinal, and last dorsal nerves, and probably the ascending branch of the deep circumflex iliac artery. If the incision be carried high up, other dorsal (intercostal) nerves are met with.

The transversalis fascia is well exposed, and is divided along the whole length of the wound.

The peritoneum is now very carefully stripped from the iliac fascia, and the external iliac artery sought for. The serous membrane is pushed aside in the manner already described (page 202), until the common iliac trunk is reached. The ureter is pushed aside (*i.e.*, upwards and inwards) with the peritoneum.

The coat of the artery is well exposed, and the needle should be passed, on either side of the body, from right to left.

There is considerable risk of injuring the vein. The ligature should be applied, if possible, to the middle of the artery.

(b) *Marcellin Duval's Operation.*—The incision is about five inches in length. It is commenced one inch and a quarter

to the outer side of the spine of the pubes, a little above Poupart's ligament. The first inch and a half of the incision is parallel with Poupart's ligament. The incision is now sharply curved upwards, and ultimately follows a line which is perpendicular to the ligament, and is directed towards a point one inch and a quarter to the outer side of the umbilicus. (*See* Fig. 57, *d.*)

The three abdominal muscles are divided, together with the transversalis fascia, and the artery is reached by pushing aside the peritoneum in the manner already described.

Comment.—The general observations made upon the operation for ligaturing the external iliac artery (page 203) apply equally to this procedure. There is great danger of wounding the peritoneum. A very efficient retraction of the soft parts is essential, and the passing of the needle is associated with considerable difficulty.

Mott himself made an incision five inches long, beginning immediately above the external abdominal ring, and continued in a semilunar direction half an inch above Poupart's ligament to a little above the anterior superior iliac spine. This incision was too low down.

The operation described is easy, so far as the exposure and separation of the peritoneum is concerned; but the vessel is reached at a great depth, and the passing of the needle is attended with considerable difficulty.

Duval's procedure would appear to be the best of the anterior extra-peritoneal operations. The artery is well and easily exposed. The wound, however, in the abdominal muscles is of considerable extent, and the conditions favourable for ventral hernia are somewhat increased. Duval's incision is convenient also for ligature of the internal iliac artery.

2. **Ligature of the Artery through a Lateral Incision.**—This operation was first carried out by Sir P. Crampton, and is described by him in the following words (*Med.-Chir. Trans.*, vol. xvi., page 161). The loin is well exposed, the patient lying upon the sound side. "The first incision commenced at the anterior extremity of the last false rib, proceeding directly downwards to the ilium. It then followed the line of the crista ilii, keeping a very little within its inner margin, until it terminated at the superior anterior spinous process of that

bone. The incision was therefore chiefly curvilinear, the concavity looking towards the navel. The abdominal muscles were then divided to the extent of about an inch, close to the superior anterior spinous process, down to the peritoneum Into this wound the forefinger of the left hand was introduced, and passed slowly and cautiously along the line of the crista ilii, separating the peritoneum from the fascia iliaca. A probe-pointed bistoury was now passed along the finger to its extremity; and by raising the heel of the knife, while its point rested firmly at the end of the finger, as on a fulcrum, the abdominal muscles were separated from their attachments to the crista ilii by a single stroke.

"By repeating this manœuvre the wound was prolonged until sufficient room was obtained to pass down the hand between the peritoneum and the fascia iliaca. Detaching the very slight connection which these parts have with each other, I was able to raise up the peritoneal sac with its contained intestines on the palm of my hand, from the psoas magnus and iliacus internus muscles, and thus obtain a distinct view of all the important parts beneath, and, assuredly, a more striking view has seldom been presented to the eye of the surgeon. The parts were unobscured by a single drop of blood; there lay the great iliac artery, nearly as large as my finger, beating awfully at the rate of two in a second, its yellowish-white coat contrasting strongly with the dark blue of the iliac vein, which lay beside it, and seemed nearly double its size. The ureter, in its course to the bladder, lay like a white tape across the artery, but in the process of separating the peritoneum it was raised from it with that membrane, to which it remained attached. . . . Nothing could be more easy than to pass a ligature round an artery so situated. The forefinger of the left hand was passed under the artery, which, with a little management, was easily separated from the vein; and on the finger (which served as a guide) a common eyed-probe, furnished with a ligature of moistened catgut, was passed under the vessel."

Comment.—Compared with Mott's operation, this procedure has certain decided advantages. The actual operation is much easier; the peritoneum is less disturbed, and is more readily separated: the artery is brought actually into view,

and the ligature is passed with comparative ease: there is a less probability of the formation of a ventral hernia: and, lastly, the wound affords better conditions for efficient drainage. Between Crampton's operation and that of Marcellin Duval there is a less conspicuous comparison. In both, the artery is well and admirably exposed. In stout and muscular subjects the lateral wound may have to be carried to a great depth; but, on the other hand, it is in a position in which the probabilities of a ventral hernia are decidedly less than in the anterior operation.

3. **The Intra-Peritoneal Operation.**—This method would be carried out upon the lines indicated in the account of the ligature of the internal iliac artery. (*See* page 213.)

The same median incision in the abdominal wall might be employed.

The operation is simple, and is without complication, and of the various methods of securing the vessel it may probably be considered to be the best, although the procedure has yet to be tested.

I am not aware that the operation has been carried out upon the living subject.

Collateral Circulation after Ligature of the Common Iliac Artery.—

Above.		*Below.*
Internal mammary and lower intercostals	with	Deep epigastric.
Lumbar	with	Deep circumflex iliac and ilio-lumbar.
Superior hæmorrhoidal	with	Hæmorrhoidal branches of internal iliac.
Middle sacral	with	Lateral sacral.
Pudic, epigastric, obturator, and visceral arteries	with	The corresponding vessels on the opposite side.

Varieties of the Iliac Arteries.—

1. The aorta may bifurcate a little below, or, in rarer instances, a little above the normal situation.
2. The common iliac arteries may bifurcate above or below the point indicated, and may vary in length between one inch and a half and three inches.
3. The deep epigastric artery may arise from the external iliac, one and a half, or even two and a half

inches above Poupart's ligament. The deep circumflex artery may arise as high as one inch above the ligament.

4. The internal iliac artery may vary in size from half an inch to three inches, and its place of division may be at any point between the upper margin of the sacrum and the upper border of the sacro-sciatic foramen.

The Internal Iliac Artery (II.).

Anatomy.—This vessel, which measures from one to one inch and a half in length, extends from the bifurcation of the common iliac to the upper margin of the great sacro-sciatic notch, where it breaks up into its ultimate branches.

It lies at first near the inner edge of the psoas muscle, and then upon the sacrum and lumbo-sacral cord. It is covered by peritoneum, and is crossed by the ureter at its commencement. The vein lies behind and somewhat to the inner side (Fig. 56). The varieties of the artery have been already detailed (page 211).

Indications.—The circumstances under which this operation is justifiable are very few. It has been ligatured for hæmorrhage, but with very unsatisfactory results. Lidell states that out of twenty-seven recorded examples of the operation, only eight recoveries can be claimed. The great majority of the successful cases are instances of ligature for the cure of gluteal aneurysm.

The operation was first performed with success by Dr. W. Stevens, of Santa Cruz, in 1812, for aneurysm (*Med.-Chir. Trans.*, vol. v., page 422). He made an incision five inches in length through the anterior abdominal parietes, parallel with the deep epigastric artery, and about half an inch to the outer side of it. The peritoneum was pushed aside, and the artery reached as in the operation for the ligature of the common iliac.

1. **The Extra-Peritoneal Operation.**—The incision employed is the same as that made to secure the common iliac artery, the procedure of Marcellin Duval being the best suited for the purpose (page 208).

The preparation of the patient, the position assumed, and

the general features and special dangers of the operations for securing the iliac arteries, have already been dealt with in the sections on the common iliac and the external iliac.

In the present case the peritoneum is pushed aside, until the external iliac is reached. The surgeon is guided to the internal artery by following the more superficial trunk. The upper margin of the great sacro-sciatic notch is easily identified, and will serve to indicate the lower end of the artery. The passing of the ligature is difficult, and many aneurysm needles, of various sizes, and with various curves, should be at hand. The needle should be passed, on either side of the body, from within out.

2. **The Intra-Peritoneal Operation.**—This procedure has been advocated by Dr. Dennis, of New York (*New York Med. News*, November, 1886). He reports three cases, in all of which the ligature was applied for aneurysm. In one case the right internal iliac was secured, and in another the left. Both patients were cured. In the third instance, both internal iliacs were ligatured. The patient, a woman of sixty, died on the third day. I ligatured the artery with success in a boy aged sixteen, for a vascular tumour of the buttock, in November, 1889, by this method.

Operation.—The abdomen is opened in the middle line by an incision extending from the symphysis pubis to the umbilicus, or to a point a little above it (Fig. 57, *f*). The intestines having been pushed up and drawn aside, the area of the deep wound is surrounded by sponges, and so cut off from the peritoneal cavity. I employed six sponges in this way, and had the wound well opened, and the sponges kept in position by two large metal retractors and one ivory spatula.

The peritoneum over the artery is thus well exposed, and is divided to the extent of one inch and a half. The artery is followed down from the bifurcation of the common iliac. The vein will appear to be about three times the size of the artery, and the separation of the two is a matter of some delicacy. Care should be taken that the ureter is not damaged nor accidentally included in the ligature. The many sympathetic nerve fibres which follow the artery may be avoided if the coat of the vessel be well exposed.

A good light, several broad retractors or spatulæ, long

dissecting forceps, and a variety of aneurysm needles, are required. The operation should be performed with the care which is essential in every abdominal section.

Comment.—The advantages of this method are obvious. The vessel is easily and fully exposed, and the needle can be passed without risk to the vein or the ureter. The operation is simple, and involves but little time. Its dangers are, comparatively speaking, very few. The ligature can be applied accurately at the spot determined upon. The condition of the artery and of the surrounding parts can be made out, and a diagnosis confirmed or modified. The great objection that some few years ago would have been urged against the procedure—the risk of acute peritonitis—may be at the present day almost disregarded.

Collateral Circulation after Ligature of the Internal Iliac Artery:

Above.		*Below.*
Middle sacral	with	Lateral sacral.
Inferior mesenteric	with	Hæmorrhoidal arteries.
Branches of profunda femoris	with	Sciatic and gluteal.
Circumflex iliac	with	Ilio-lumbar.
Internal pudic and obturator	with	the vessels of the opposite side.

BRANCHES OF THE INTERNAL ILIAC ARTERY.

1.—**The Gluteal Artery** (III.).

Anatomy.—This, the largest branch of the internal iliac artery, turns round the upper margin of the great sacrosciatic foramen, and divides opposite the interval between the gluteus medius and pyriformis, into two divisions, a superficial and a deep. The former passes backwards between the gluteus medius and pyriformis, and reaches the great gluteus.

The latter runs forwards between the gluteus medius and gluteus minimus.

The vein lies anterior to the trunk of the artery, and the superior gluteal nerve is placed a little below it.

Line of the Artery.—If a line be drawn from the posterior superior iliac spine to the top of the great trochanter, when the thigh is rotated in, a point at the junction of the upper with the middle third of that line will correspond to

the point at which the gluteal artery emerges from the sciatic notch (Fig. 60, A, B).

Indications.—This operation can very rarely be called for. It has been performed with success in cases of stab wound, in a case of hæmorrhage following the evacuation of a gluteal abscess, and in certain examples of false aneurysm.

It was first ligatured by John Bell in 1808 for false aneurysm ("Principles of Surgery").

Operation.—The patient is rolled nearly over on to the face; the limb is allowed to hang over the edge of the table; the thigh is rotated in. The surgeon stands upon the side to be dealt with.

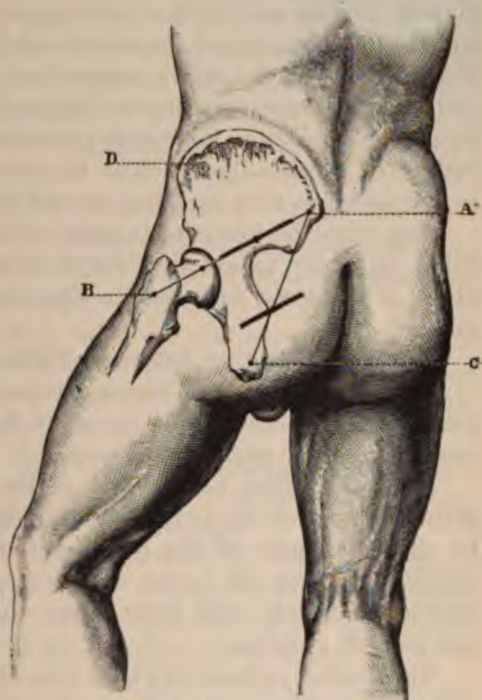

Fig. 60.—THE INCISIONS FOR THE GLUTEAL, SCIATIC, OR PUDIC ARTERIES.

A, Post. sup. iliac spine; B, Great trochanter; C, Tuber ischii; D, Ant. sup. Iliac spine; A-B, Gluteal line; A-C, Sciatic and pudic line (MacCormac).

An incision five inches in length is made along the line just given. The centre of the incision should correspond to the point of exit of the artery (Fig. 60).

After dividing the skin and superficial fascia with a few cutaneous nerves, the gluteus maximus is reached, covered by its fascia. The incision runs parallel with the fibres of the muscle.

These fibres are separated in the line of the wound until the thickness of the muscle has been traversed. A muscular branch—from the superficial division of the artery—may here be met with, and will form a guide to the trunk.

The deep fascia between the glutei muscles is reached, and the contiguous margins of the gluteus medius and pyriformis muscles are exposed.

The gluteus maximus is now relaxed by placing the fully extended thigh upon the table. The interval between the gluteus medius and pyriformis is opened up with retractors, and the upper margin of the sciatic notch defined. The superficial division of the artery passes between the two muscles, and leads the operator's finger to the main trunk. The ligature should be applied as far within the notch as possible—almost within the pelvis,—inasmuch as the artery breaks up into its two divisions as soon as it has cleared the notch

Care must be taken to include neither the nerve nor the vein. In order to obtain a fuller view of the vessel, some fibres of the great sacro-sciatic ligament may require to be divided.

2.—**The Sciatic or Internal Pudic Arteries** (IV.).

The ligature of these vessels has scarcely ever been called for in actual practice. The operation has been performed for some uncommon examples of wound.

Anatomy.—The sciatic and pudic arteries descend together in front of the pyriformis muscle, and leave the pelvis by the lower part of the great sacro-sciatic foramen. The sciatic continues its course downwards under cover of the gluteus maximus, and rests upon the obturator internus and gemelli muscles.

The pudic curves forward over the ischial spine, and enters the pelvis again by the small sacro-sciatic foramen.

At the lower margin of the pyriformis muscle the sciatic artery is superficial to the pudic, and passes behind it to gain its outer side. Both vessels are accompanied by venæ comites. To the inner side of the pudic artery, at the lower border of the pyriformis, lie the internal pudic nerve and its inferior hæmorrhoidal branch.

The sciatic artery, near the same place, is superficial (*i.e.*, posterior) to both the small and the great sciatic nerves.

Operation.—The point at which the sciatic and pudic arteries emerge from the pelvis and reach the gluteal region is indicated by a line drawn (when the thigh is rotated in) from the posterior superior iliac spine to the outer part of the

tuber ischii (Fig. 60, A—C). The point in question is at the junction of the middle with the lower third of this line.

An incision, some four inches in length, is made obliquely across this line in the direction of the fibres of the gluteus maximus, and is so placed that its centre corresponds to the point just indicated (Fig. 60).

The gluteus maximus is divided in the line of the wound, and the lower margin of the pyriformis muscle and the spine of the ischium are well defined.

The ligature should be passed as near to the pelvis as possible.

THE ABDOMINAL AORTA.

So far as the present history of this operation is concerned, the ligation of the abdominal aorta can scarcely be considered to be a justifiable procedure.

It has been resorted to in severe cases of iliac and inguinal aneurysm which have resisted all other modes of treatment, and has been practised for the arrest of both primary and secondary hæmorrhage.

The aorta was first ligatured by Sir Astley Cooper in 1817 ("Prin. and Prac. of Surgery," vol. i., page 228), by opening up the abdominal cavity in the median line.

The second operation was performed by James, of Exeter, in 1827 (*Med.-Chir. Trans.*, vol. xvi., page 10). He followed the procedure of Cooper. His patient lived a few hours only. Cooper's patient survived the operation forty hours.

The third operation was carried out by Murray, at the Cape of Good Hope, in 1834 (*Lond. Med. Gaz.*, vol. xiv., page 68). He reached the artery by a lateral incision, and did not open the peritoneal cavity. The patient died in twenty-four hours.

The fourth and—in certain respects—the most important case was in the charge of Monteiro, at Rio Janeiro. He ligatured the aorta in 1842 by the extra-peritoneal method, using the incision employed by Murray. The patient lived ten days, and died of secondary hæmorrhage (*Schmidt's Jahrbucher*, 1843).

Since then the operation has been performed by South, Hunter, McGuire, Stokes, Watson, Czerny of Vienna, and Czerny of Heidelberg.

There are eleven cases in all, and all eleven patients died

within a comparatively short time of the operation. The most successful case was that of Monteiro, whose patient lived ten days.

As the majority of these operations were carried out before the introduction of antiseptic methods in surgery, and before the recent improvements in ligature material had been effected, it may reasonably be argued that they do not form an argument for the absolute abandonment of the operation.

Cooper's patient appears to have died of acute peritonitis, a complication that may, with some certainty, be avoided at the present day.

Monteiro's patient might possibly have escaped death from secondary hæmorrhage had the operation been performed antiseptically, and had a more suitable ligature been employed.

This case alone would appear to sanction the ligature of the aorta in desperate cases of iliac or inguinal aneurysm, when every other mode of treatment had failed.

It must not be forgotten, however, that when a spontaneous aneurysm involves one or other of the iliac arteries, it cannot be expected that the walls of the aorta itself will be free from disease.

Anatomy.—The point of bifurcation of the aorta has been already described (page 206). The vessel at its lower part is covered by the peritoneum only, and upon the front of the artery, and beneath the serous membrane at this point, are the important sympathetic nerve cords, which pass from the aortic to the hypogastric plexus. The aortic plexus lies along the aorta, between the origins of the superior and inferior mesenteric arteries. The hypogastric plexus lies in the interval between the two common iliac arteries. Much areolar tissue surrounds the vessel, and the vena cava lies to its right side. The inferior mesenteric artery arises between one and two inches above the bifurcation of the aorta, and it is between this vessel and the origin of the common iliacs that the ligature should be applied.

1. **The Intra-Peritoneal Operation** (Astley Cooper).—The patient lies upon the back, with the shoulders raised. An incision, three to four inches in length, is made in the linea alba, the centre of the incision corresponding to the umbilicus. The peritoneal cavity is opened, and the intestines having

been drawn aside, the serous membrane covering the vessel is neatly divided. The artery should then be well bared midway between the bifurcation and the origin of the inferior mesenteric artery, as it is of primary importance that none of the sympathetic nerve fibres should be included in the ligature. The great vessel is best isolated with the finger. The needle must be passed from right to left, and care must be taken not to damage the vena cava. A stout piece of chromicised catgut of large size will be required. The operation needs a good light, a reflector or an electric lamp, broad spatulæ, and an especially long aneurysm needle, with such a curve as the operator's own experiments upon the cadaver have shown to be the most convenient.

2. **The Extra-Peritoneal Operation** (Murray).—This operation involves a very deep and complicated wound. The vessel is reached with difficulty, and the passing of the needle is attended with considerable danger. The procedure would not have been described had it not been the method which was carried out in the most successful of the eleven cases—viz., in Monteiro's case.

A curved incision—with the concavity forwards—measuring about six inches, is made upon the left side of the body, from the extremity of the tenth rib to a point about one inch to the inner side of the anterior superior iliac spine. The three abdominal muscles and the transversalis fascia are divided in the manner already described in the operation for ligaturing the common iliac artery. The peritoneum is separated from the iliac fascia; the common iliac trunk is in this way reached, and the surgeon's fingers are gradually led to the aorta itself. The vessel should be isolated as well as is possible by the finger. It should be bared of the areolar tissue around it, in order to avoid the inclusion in the ligature of the sympathetic nerve trunks.

The needle is passed from left to right, the vein being protected by the forefinger.

Part IV.

OPERATIONS UPON NERVES.

CHAPTER I.

INTRODUCTORY.

THE following are the operations which are considered in this connection.

1. Nerve stretching.
2. Neurotomy, or section of a nerve trunk.
3. Neurectomy, or excision of a portion of a nerve trunk.
4. Neurorraphy, or suture of a divided nerve trunk.

These operations are all of comparatively modern origin. The good effect of nerve stretching upon irregular muscular contractions was observed by Nussbaum in 1860 in a case in which the ulnar nerve was accidentally stretched during an excision of the elbow. Billroth met with a similar accidental experience in 1869. In 1872 Nussbaum practised the first intentional nerve stretching.

With the appearance of Vogt's monograph in 1877 conspicuous attention was drawn to the subject, and a few years later the operation was introduced into England.

Neurotomy for neuralgia and more especially for neuralgias of the face, is not a very modern operation. It was practised by Maréchal in the middle of the 18th century, and in 1798 John Haighton published an account of "a case of tic douloureux or painful affection of the face, successfully treated by a division of the affected (infra-orbital) nerve." Subsequent to this the operation appears to have been so frequently and so recklessly employed that the procedure sank into disrepute. It was revived again about 1852 by Roux and others, and was placed upon a more sound basis.

The suture of nerves has for centuries attracted the notice

of surgeons, but the matter received little but theoretical treatment. In 1776 Cruikshank established the reality of the cicatrisation of nerves, and the work of Weir Mitchell upon gunshot injuries of nerves, published in 1864, drew notable attention to the clinical features of certain nerve lesions. In the same year, Laugier and Nélaton performed what was probably the first definite and well-planned neuroraphy. They were certainly the first to give a precise account of the operation.

1. **Nerve Stretching.**—This procedure has been applied to nerves of all kinds, both large and small, to motor and sensory nerves, as well as to those of mixed composition. During the period at which a rage for nerve stretching existed even the optic nerve was stretched in cases of loss of vision (Wecker 1881, Parnard 1882).

The measure has been employed in the treatment of various forms of muscular spasm (*e.g.*, wry neck, *tic convulsif*, tetanus), in peripheral neuralgias, in peripheral neuritis, in sciatica, in reflex epilepsy, in cases of hyperæsthesia, painful ulcer and painful stump, and for the relief of anæsthesia in leprosy, and lightning pains in locomotor ataxy. The results have, on the whole, not been very satisfactory. The best effects have been obtained in certain cases of sciatica and of peripheral neuritis, in a proportion of the examples of neuralgia, and in instances of spasmodic contraction of muscles.

The extensibility of nerves varies greatly, and is influenced by the size and situation of the trunk, its condition, the age and general state of the patient.

It is said that a weight of about 6 lb. 10 oz. is required to extend the median nerve of an adult man three-fourths of an inch, and that the elasticity of the nerve is such, that it will return to its normal length when the extending force is removed, even when the tension has been maintained for a few hours.

Nerve trunks are more extensile near the spinal cord than at a distance, and in the upper than in the lower limb. This depends probably upon the strength of the nerve sheath, which is subject to variation, and against which the main strain of the stretching is directed.

Modus Operandi.—The nerve is exposed at its most convenient and usually at its most superficial part, and is then clearly isolated and brought well into view.

In the limbs the joints may be so flexed as to relax the parts about the site of the operation. Good retractors will usually be required. The larger nerve trunks are stretched by means of the finger and thumb, smaller nerves by means of a suitable blunt hook, and the smallest cords by the aid of a probe or director.

"The nerve," writes Mr. Horsley, "being firmly held between the finger and thumb, is then to be steadily pulled for about five minutes, first centrifugally, and then centripetally for a like period of time. The tension must be gradually applied and kept constant the whole time, while all jerks (the force of which is unknown) are to be avoided. The actual amount of force with which it is advisable to pull, varies from a maximum of thirty pounds for the sciatic nerve, to half a pound for the supra-trochlear. The amount of force must necessarily vary with individual development and the state of the nerve (Marshall). It will now be found that the nerve is loose and elongated, owing to its elasticity being relatively very imperfect." With regard to the sciatic nerve Marshall writes, "If I first pull as hard as I imagine I should do upon a living sciatic nerve during an operation, I find that the force employed is about equal to twenty pounds; but if I pull very hard, it is increased to thirty pounds; and that, I believe, is as hard as a surgeon could well pull when holding a soft nerve between his finger and thumb."

The nerve having been replaced, the incision is closed.

The part should be kept absolutely at rest until the wound has entirely healed. Active and passive movements of the limb should then be gradually carried out, and some form of simple massage be employed.

2 and 3. **Neurotomy and Neurectomy.**—These operations have been adopted in the treatment of similar cases to those mentioned in the previous paragraph. They are of necessity limited to smaller nerves, and in nearly every instance to such nerves as are purely sensory.

In cases of peripheral neuralgia, and in certain painful affections — such as cancer of the tongue — neurotomy or

neurectomy has met with a certain amount of success. In the neuralgic cases there is a great disposition to relapse after a varying period. The patients are often not the best subjects for operation; many are hysterical, and in not a few possibly the diagnosis has been ill-considered and the time ill-selected.

The nerve is exposed at some "place of election," and is dealt with by one or other of the methods named.

The majority of these operations are not of great gravity.

4. **Neuroraphy.**—This operation concerns the union of nerve trunks which have been severed by accident.

The term "immediate suture" is applied to cases in which the divided ends of the nerve are united within a short time of the accident; the term "secondary suture" to instances in which a period of time varying from weeks to months has elapsed between the receipt of the injury and the operation. It is needless to say that the former measure is the simpler and by far the more successful.

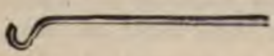

Fig. 61.—HOOK USED IN NEUROTOMY OR NEURECTOMY. (*Natural size.*)

In the *immediate suture*, the wound is perfectly cleaned, the cut ends of the nerve are brought together and united by sutures. Any bruised or jagged part of the exposed nerve is cut away. The general features of the operation are identical with those now to be described.

In the *secondary suture* the steps of the procedure are as follow:—

1. The nerve is exposed. The incision is made over the course of the nerve, and parallel to it. This part of the operation may be complicated by the presence of much cicatricial tissue and many adhesions, by wasting of adjacent muscles, by deformity, by the existence of a mass of callus about a fracture, and by much retraction of the nerve itself. In most instances the use of an Esmarch's tourniquet is not to be advised. Even in a case of simple division of the nerve by a stab, an interval of from a half to one inch may be found to separate the divided ends. In instances where there has been much destruction, the interval may be greater.

The upper end of the nerve is more easily found than the lower. It is usually enlarged, bulbous, and sensitive.

The lower end, on the other hand, is usually atrophied and

filiform, and is apt to be lost in cicatricial tissue, and to be free from notable sensation.

It may be necessary to expose the trunk of the nerve lower down and then to follow the cord upwards, in order to find the "lower end" with greater certainty.

In any case the operator must be prepared to make a very free wound.

Each portion of the exposed nerve should be freed for some distance respectively upwards and downwards, and the ends carefully drawn up in order to bring as much of the nerve as possible into the wound area to overcome the gap resulting from retraction, and to allow the extremities to be brought readily in contact.

2. The two exposed ends are excised. This is best done with sharp small scissors. The cut must be clean and quite transverse. The bulb may be cut away layer by layer until a section of healthy nerve fibres is exposed. It is not always necessary to remove the whole of the bulbous end. Indeed, the firmer tissues of the bulb afford an excellent hold for the sutures. Bowlby advises that the section should pass through the upper end of the bulb, close to the trunk.

With regard to the lower end of the nerve, Bowlby advises that it is only necessary "to cut away the extreme end, which, being matted with fibrous tissue and compressed by the surrounding scar, is very likely to contain no nerve tubules. It is seldom necessary to remove as much as $\frac{1}{4}$ inch, and however unhealthy the section may look, no good is ever to be gained by a further sacrifice."

3. The two ends are united by sutures. From 2 to 6 or 8 sutures will be required, according to the size of the divided nerve. The material should be either fine silk or chromicised catgut or the finest silkworm gut. Some surgeons especially recommend kangaroo tendon sutures. The thread is passed by means of a Hagedorn's curved needle. A small "intestinal" needle answers admirably. The needle should be introduced about $\frac{1}{4}$ of an inch from the free end of the nerve, and the thread should be carried through the whole thickness of the trunk. If the sheath be substantial or use can be made of the cicatricial tissue around the nerve, the sutures may be introduced into the extra-neural structures. Sutures, however,

which are limited to the sheath are of very little use. No harm has been shown to follow the passing of the needle through the substance of the nerve. If six sutures are to be applied, three may involve the nervous cord and three the sheath, or connective tissue dissected up with it. The ends must be brought into close contact and be very accurately adjusted.

All rough handling of the nerve must be avoided.

4. The wound is closed. No drainage tube is required, and every care should be taken to ensure the healing of the wound by first intention. The limb should be so adjusted that the parts concerned in the operation wound are relaxed, and no traction is brought to bear upon the sutured nerve. For example, if the nerve concerned be the median in the forearm, both the elbow and the wrist joints should be flexed. The parts must be rigidly maintained in the desired position by means of splints, and should be well protected and kept warm.

As soon as the wound has soundly healed, passive movements, together with massage and galvanism, may be cautiously employed.

The result of neuroraphy must depend upon many circumstances—upon the nature of the injury, the lapse of time since the nerve was divided, the amount of separation of the two ends, the local condition, the state of the patient's health, the amount of degeneration which has taken place, and the readiness with which the operation wound has healed. In any case it must be remembered that a very considerable time must be allowed to elapse before the surgeon can form an opinion as to the final results of the operation. Complete restoration of function will often require one or two years, and no improvement of any kind may be evident for several months after the neuroraphy.

Subjoined is an account of the *methods of exposing* the nerves most usually subjected to operation. Comparatively few nerves are dealt with, and no attempt has been made to give a description of all the operations which have been, or may be performed. There are few of the superficial nerves of the body which have not been cut down upon at one time or another. In the limbs many of the nerves are exposed through the incision required for the ligature of the companion artery, as for example the anterior or posterior tibial.

CHAPTER II.

Operations upon the Nerves of the Head and Neck.

THE FIRST DIVISION OF THE TRIFACIAL NERVE.

The Supra - Orbital Nerve. — *Anatomy.* — This nerve escapes through the supra-orbital notch and ascends vertically upwards. The notch is situated at the junction of the middle with the inner third of the upper orbital margin. At this spot the nerve lies beneath the orbicularis palpebrarum, and is usually found to have already broken up into two divisions. It is accompanied by the supra-orbital vessels which lie to its outer side (Figs. 62 and 63).

Operation.—The eyebrow is steadied by the operator's left hand while an assistant draws the eyelid downwards. An incision about three-quarters of an inch in length is made horizontally along the superior orbital margin in such a way that its centre will correspond to the supra-orbital notch. The integuments and orbicularis muscle having been cut through, the nerve is readily exposed. The vessels should be avoided.

Comment.—A vertical incision exposes more of the nerve, and is simpler, but it makes a more considerable section of the muscle and leaves a larger scar.

THE SECOND DIVISION OF THE TRIFACIAL NERVE.

Anatomy.—The superior maxillary nerve pursues a nearly horizontal course from the foramen rotundum to the infra-orbital foramen on the anterior surface of the upper jaw. If the course of the nerve be followed the distance between these two foramina is, in the adult skull, about two inches.

At the infra-orbital foramen the nerve breaks up into its ultimate cutaneous branches, viz., the palpebral, labial, and nasal (Figs. 62 and 63).

A little beyond the foramen rotundum the nerve crosses the

spheno-maxillary fossa, and at the spot where it bridges over this fossa, Meckel's ganglion is found.

The distance from the infra-orbital foramen (on the face) to Meckel's ganglion can seldom be less than 1¾ inch.

The following is the guide for the infra-orbital foramen. A line is drawn downward from the supra-orbital foramen

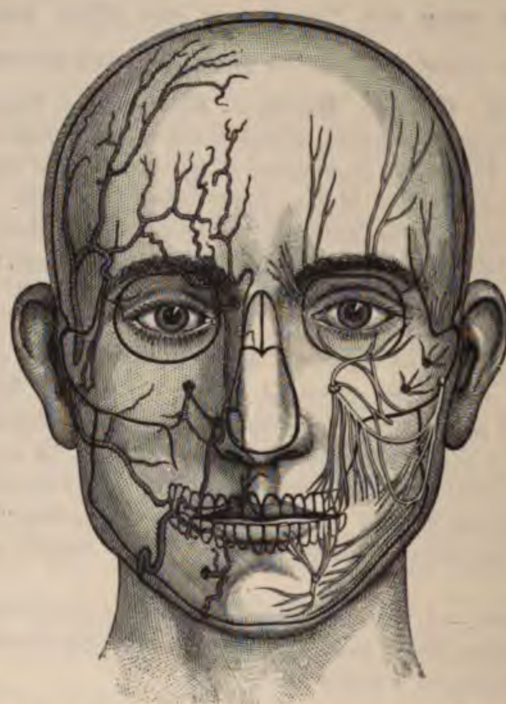

Fig. 62.—THE NERVES OF THE FACE AND THEIR RELATIONS TO THE ARTERIES OF THE REGION. (*From Meckel.*)

(page 227) so as to cross the gap between the two bicuspids in both jaws. This line will cross both the infra-orbital and the mental foramina. The former is just above the canine fossa and about a quarter of an inch below the margin of the orbit.

Meckel's ganglion is a triangular body with a diameter of about one-fifth of an inch. It is surrounded by the terminal branches of the internal maxillary artery, and has

the following relations. Above it is the superior maxillary nerve, behind it are the sphenoid bone and the vidian canal, on its outer side are the termination of the internal maxillary artery and the external pterygoid muscle, and on its inner side are the vertical plate of the palate bone and the spheno-palatine foramen.

As this nerve is often dealt with in the treatment of neuralgia involving the upper teeth, the position of its branches is important. Within the skull it gives off the recurrent branch to the dura mater. Between the foramen rotundum and the ganglion comes off the orbital branch. Between the ganglion and the superior maxilla, *i.e.*, at the point of entrance into the infra-orbital canal, arises the posterior dental branch which supplies the molars. At the hinder part of the canal and within the maxilla takes origin the middle dental nerve which supplies the bicuspid and canine teeth. The incisor teeth are supplied by the anterior dental nerve which arises at the anterior part of the canal close to the infra-orbital foramen.

In order therefore that all the dental nerves might be severed, the nerve trunk must be divided as far back as Meckel's ganglion.

The posterior half of the infra-orbital canal is open to the orbit, and exists as a groove merely, the anterior half has a bony roof and takes therefore the form of a genuine osseous canal. Occasionally the whole or part of the posterior portion of the so-called canal has a bony roof, and in such case no part of the nerve could be exposed from the orbit without cutting through a thin plate of bone.

The infra-orbital vessels which accompany the nerve in the infra-orbital canal are small and have an inconstant relation to the nerve, although they more usually lie to its outer side. In one instance I found the artery winding around the nerve.

1. **The Infra-Orbital Nerve.** — *Operation.* — This nerve may be exposed as it leaves the infra-orbital foramen by means of a transverse incision three-quarters of an inch in length made about a quarter of an inch below the lower margin of the orbit, and so placed as to cross the infra-orbital foramen (Figs. 62 and 63).

After the skin, layer of subcutaneous fat, and orbicularis

muscle have been divided, the levator labii superioris is exposed and must be severed in the line of the original wound. The nerve is now reached and can be dealt with. The parts are vascular and the view of the nerve is apt to be occluded by free bleeding.

Comment.—Section of the nerve at this spot cuts off merely the terminal branches to the face. Subcutaneous division of the nerve through the mouth has been advised, but experience has shown that in the treatment of neuralgia mere division of the terminal fibres of a nerve is of little service.

Various methods have been devised for dealing with the infra-orbital nerve nearer to its commencement by exposing it through the floor of the orbit.

An incision is made along or near the lower margin of the orbit, the orbital fascia is divided and the contents of the cavity are displaced upwards by means of a thin spatula.

The infra-orbital groove is exposed and the nerve divided as far back as possible. If the terminal part has been brought into view through the skin incision, a considerable part of the nerve might be drawn out after the division.

These operations are unsatisfactory. The wound is very deep and the area of the operation is exceedingly narrow. The orbital tissues are disturbed and the globe and its nerve apparatus are exposed to danger. Moreover, unless the nerve be divided as far back as the commencement of the infra-orbital groove only the anterior dental nerve will be removed by the neurectomy. Severe hæmorrhage into the orbit and exomphalos have followed these measures. The statement that the nerve has been divided as far back as the spheno-maxillary fossa when exposed through the orbital floor may be open to some question.

2. **The Trunk of the Superior Maxillary Nerve and Meckel's Ganglion.**

In some forms of intractable neuralgia the nerve has been divided on the distal side of the foramen rotundum and the whole trunk removed as far forwards as the infra-orbital foramen, together with Meckel's ganglion.

Operation.—A -shaped incision is made on the front of the cheek so placed that the apex points directly downwards

and the centre of the **V** is opposite to the infra-orbital foramen. The incision should form two sides of an equilateral triangle, each limb of which measures a little more than one inch (Fig. 65, B).

The knife is carried at once down to the bone, and the triangular flap formed by the soft parts is turned up over the lower lid. A long silk suture is introduced into the apex of the flap, in order that it may be drawn well upwards out of the surgeon's way.

The infra-orbital nerve is sought for and isolated as it is emerging from the foramen. The bone having been cleared, a portion of the anterior wall of the antrum measuring from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch square is removed with a chisel and mallet. The infra-orbital foramen will be a little above the centre of the part removed. The mucous lining of the antrum having been divided that cavity is fully opened. In order that the rest of the operation may be conveniently performed, a small electric lamp is needed which may be fixed to the surgeon's forehead. In no operation is a good light more essential.

The posterior wall of the antrum is now exposed, and a portion about $\frac{1}{4}$ of an inch square is cut away with a fine chisel and mallet.

In removing the two portions of bone some surgeons use trephines—a half-inch trephine for the anterior wall and a quarter-inch for the posterior. The chisel is, however, by far the more convenient and precise instrument, and inflicts a less degree of injury upon the surrounding tissues.

The hæmorrhage is very free, and some little time may now be devoted to arresting it as far as is possible.

The next step consists in dividing the mucous lining on the roof of the antrum, under the course of the infra-orbital canal. The bone forming the floor of this canal must be broken away from one end of the maxilla to the other. This is best effected by means of scissors, aided by a fine carpenter's bradawl and a slender bone elevator or stout director. The bone is thin and offers little resistance, and the nerve, which must be most carefully preserved and carefully followed line by line, forms the guide to the surgeon's movements. Much bleeding may be expected from the damaged infra-orbital vessels, which can seldom be surely isolated. When the posterior wall of the

maxilla is reached, the white and conspicuous nerve will be hanging loose in the cavity of the antrum. Slender dissecting forceps with long blades are needed during this stage, and become still more necessary when the region of the foramen rotundum is reached.

The bone of the hinder wall of the antrum must be so completely removed that the nerve is seen to hang free in the cavity produced. The wound may now be stuffed for a while with a conical piece of sponge in order that the hæmorrhage, which is still free, might be held a little in check.

By means of the long slender forceps and a director the surgeon endeavours to make out the position of the trunk as it issues from the foramen rotundum, and, if possible, the precise locality of the ganglion. In this attempt he is aided by the infra-orbital nerve upon which traction (by means of a silk thread) is maintained. Finally the superior maxillary nerve is divided close to the foramen rotundum by a pair of very slender curved scissors, and any branches which still hold the nerve in position having been divided, the whole trunk is removed with the ganglion attached.

At this step of the operation also much bleeding may be expected. The nerve cord removed should measure not less than one inch and three-quarters.

The antrum having been sponged out the skin incision is united by sutures and the selected dressing applied. A small drainage tube should be maintained in the lower angle of the wound for the first twenty-four hours.

Comment.—The operation above described is a modification of the procedure introduced by Carnochan of New York, (*Amer. Journ. Med. Sc.*, 1858, page 136) who appears to have been the first surgeon to have excised the superior maxillary nerve. An excellent account of "neurectomy of the second division of the fifth nerve" is given by Chavasse in the *Medico-Chirurgical Transactions* for 1884. Chavasse has collected twenty-two examples of Carnochan's operation. In three only of these does the relief appear to have been permanent. In most, if not in all of the cases, a trephine was used.

I have performed the operation five times during the last ten years. In all, the wound healed well and soundly. In one instance facial erysipelas developed, but with this exception

the operation was followed by little or no constitutional disturbance The deformity produced was quite insignificant, and the scar was by no means conspicuous. In the two severest cases the neuralgia returned at the end of three years and two years respectively. One patient died of cancer six months after the operation. In the remaining two patients the pain returned within twelve months. In one of these I was not sure that I had succeeded in removing the ganglion.

Other Methods of Performing this Operation are described by Chavasse in the following words:—

Professor Lücke, of Strasburg, makes an oval incision "from a point just above the external canthus of the eye, passing at first backwards, then downwards and forwards, and terminating at the zygomatic process of the upper jaw. The masseter muscle is divided and the zygomatic arch sawn through anteriorly, and fractured posteriorly. This piece of bone, with the temporal fascia attached to it, is turned upwards. By these means the spheno-maxillary fossa is reached, and the nerve is cut as it emerges from the skull. The fractured bone is then replaced and the masseter muscle attached to it with sutures. Union of the bone shortly takes place. . . . . The drawback to it is the contraction of the muscle which is apt to follow, leading to depressed cicatrices, and thus necessitating prolonged after-treatment.

"To obviate this difficulty Professor Lossen, of Heidelberg, has modified the operation by dividing the temporal fascia along the upper edge of the zygoma, then, after fracturing the bone, turning it backwards with the masseter left intact. After replacement of the bone, the temporal fascia is stitched in its old position, and the masseter is unable to draw the bony fragment downwards. . . . . Reyher operated by first tying the common carotid artery and then cutting away the nerve, according to the plan of Lossen. Nussbaum and Billroth have also cut away portions of the superior maxillary nerve by means of Langenbeck's osteo-plastic resection of the upper jawbone, and, still more recently, Gerster has advocated a modification of this procedure by sawing through the middle of the malar bone."

These various measures are all needlessly seve and involve wounds of great and unnecessary magnitude

Since it is to be questioned whether this neurectomy is of

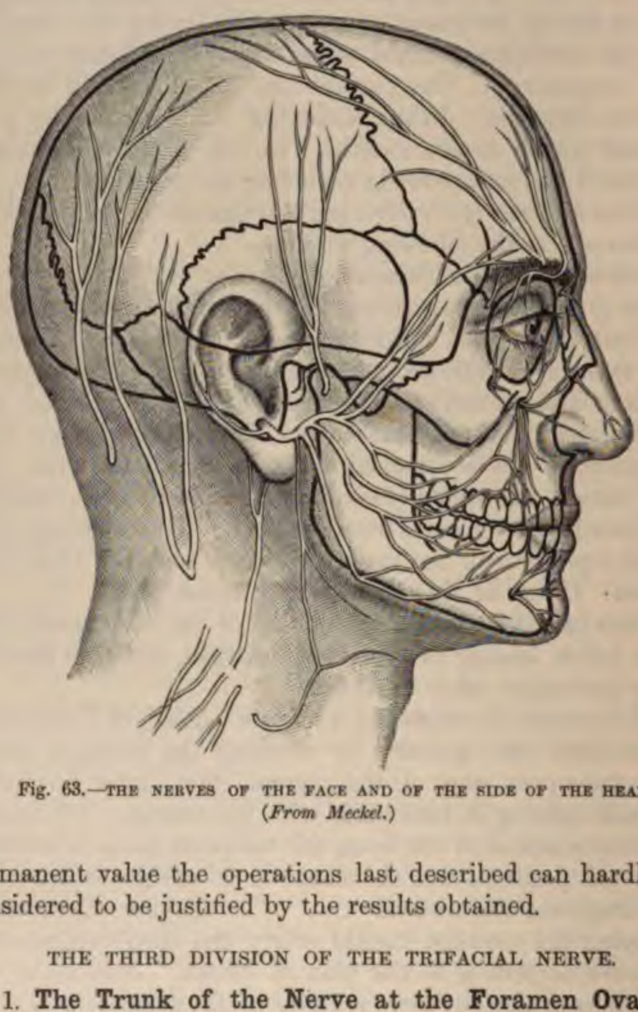

Fig. 63.—THE NERVES OF THE FACE AND OF THE SIDE OF THE HEAD. (*From Meckel.*)

permanent value the operations last described can hardly be considered to be justified by the results obtained.

THE THIRD DIVISION OF THE TRIFACIAL NERVE.

1. The Trunk of the Nerve at the Foramen Ovale.

Anatomy.—The nerve on leaving the foramen ovale is immediately joined by the motor part of the fifth nerve (Fig. 64). A little way below the foramen the nerve breaks up into two divisions, an anterior small or upper division, and a posterior, large, or inferior division. From the trunk arise four nerves —the recurrent branch to the dura mater, which enters the

skull through the foramen spinosum; the internal pterygoid nerve; and the nerves to the tensor tympani and tensor palati.

From the anterior division arise four nerves, the temporal (anterior, middle and posterior); the masseteric (from the posterior temporal); the buccal (with the anterior temporal); and the external pterygoid (Figs. 64, 66, and 67).

Fig. 64.—DIAGRAM OF THE THIRD DIVISION OF THE FIFTH NERVE.

F O, Foramen ovale (below this the motor root joins the nerve); F S, Foramen spinosum; R, Recurrent branch; A T, Auriculo-temp. nerve; M H, Mylo-hyoid nerve; I D, Inferior dental nerve; G, Gustatory nerve; E P, External pterygoid branch; B, Buccal nerve: A T, Ant. temporal nerve; M T, Mid. temporal nerve; M, Masseteric nerve; P T, Post. temporal nerve; T P, Branch to tensor palati; T T, Branch to tensor tympani; I P, Internal pterygoid branch.

From the posterior division arise also four nerves, the auriculo-temporal, the gustatory, the inferior dental, and the mylohyoid.

The foramen ovale is situated opposite to the eminentia articularis at the root of the zygoma, and is about one inch and a quarter from that process of bone, lying in a line transverse to the long axis of the skull. The foramen is about a quarter of an inch in front of the spinous process of the sphenoid, and is immediately behind the free edge of the pterygoid plate. These two points of bone, together with the eminentia articularis form excellent landmarks.

The small meningeal artery which passes through the foramen ovale can scarcely escape division. The middle meningeal which enters the foramen spinosum is in great risk. The trunk of the nerve and the larger division lie under cover of the external pterygoid muscle.

The internal maxillary artery crosses the inferior dental, gustatory, and buccal nerves, but lies below the main trunk of the nerve. In forty per cent. of bodies the artery passes beneath the lower head of the external pterygoid and then emerges between that head and the upper one. The extensive pterygoid plexus of veins lies with the artery over the muscle in question.

Operation.—A square vertical flap is cut from the cheek. The two sides of the flap are represented by two vertical lines which are parallel with the anterior and posterior borders of the ascending ramus of the jaw. The base of the flap is represented by a transverse line joining the two vertical incisions about half way down on the ramus of the jaw. The free end of the flap is a little above the zygoma (Fig. 65, A). The incisions are carried down to the bone at the free end of the flap. The zygomatic arch is exposed and its two ends are sawn through. The piece of bone is turned down together with the masseter attached to it, and the soft parts covering the upper part of the ramus of the jaw.

Care must be taken not to damage the facial nerve nor the parotid duct, both of which are below the base of the flap. The flap is drawn forcibly downwards rather than dissected up. After the bleeding has been arrested the coronoid process is divided and with the attached temporal muscle is turned upwards. The upper head of the external pterygoid muscle is separated from its attachment to the sphenoid, and the nerve can now be exposed and divided with scissors (*see* Figs. 66 and 67).

Comment.—The method described is that known as Krönlein's. The operation was first performed by Pancoast of Philadelphia some twenty years ago, and has been many times repeated. Pancoast's flap was made from below upwards and had its base at the zygoma. He ligatured the internal maxillary artery and entirely removed the coronoid process. The hæmorrhage from the operation wound is considerable, and in one case at least (Sutton's) the common carotid had to be tied to arrest it.

The procedure is attended with much risk, and involves considerable damage to important tissues. It has not been followed in all instances by such benefits as would appear to justify the operation. It involves paralysis of the muscles of mastication upon the side dealt with, paralysis of the mylohyoid and anterior part of the digastric, and probable loss of power in the tensor tympani and tensor palati. The gustatory nerve is of necessity divided.

2. **The Inferior Dental Nerve.**

Anatomy.—This nerve, the largest branch of the third

division of the fifth, descends under cover of the external pterygoid muscle, passes to the outer side of the internal pterygoid, and running between the internal lateral ligament and the ramus of the jaw, enters the dental foramen (Figs. 66 and 67).

This foramen is surmounted by a prominent and usually sharp projection of bone, the lingula or spine of Spix. To its apex is attached the internal lateral ligament of the jaw, while below and behind it is the groove for the mylo-hyoid nerve.

The internal pterygoid muscle reaches to the base of the lingula.

The nerve is accompanied by the inferior maxillary vessels which lie behind and external to it.

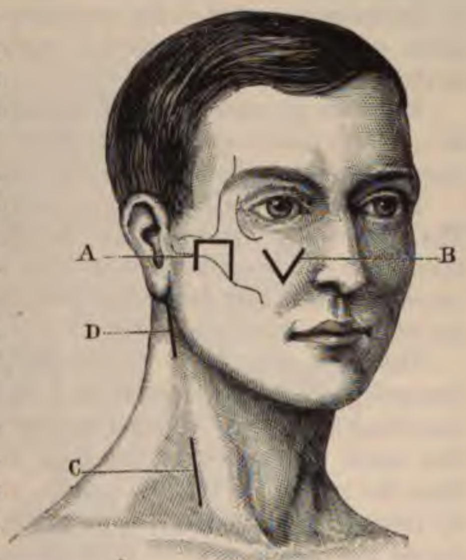

Fig. 65.—A, Neurotomy of third division of fifth nerve; B, Removal of Meckel's ganglion; C, Exposure of brachial plexus; D, Exposure of spinal accessory nerve.

The internal maxillary artery passes forwards and inwards at some distance above the dental foramen. The gustatory nerve is nearly parallel with the inferior dental, but is anterior and internal to it and—as viewed from the mouth—is superficial to it.

Operation.—The mouth is fixed well open by a Mason's gag applied upon the opposite side or by a Hutchinson's spring mouth-prop placed between the incisor teeth. The cheek upon the side to be dealt with is held open by means of two blunt hooks which are so drawn upon as to make the opening of the mouth at this angle as wide and as square as possible. If the tongue be in the way it may be drawn aside with tongue forceps.

A good light is essential, and the best is that given

by a small electric lamp worn upon the forehead. The surgeon with his forefinger defines the ascending ramus of the jaw, the substance of the internal pterygoid muscle, and the position of the spine of Spix. This latter point is more or less obscured by the attachment of the internal lateral ligament. If the tongue be drawn upon the gustatory nerve may possibly be felt beneath the mucous membrane.

The mucous membrane is now incised along the inner side of the anterior border of the ascending ramus to the extent of about one inch. The incision is vertical and is carried down to the bone.

A narrow pointed periosteal elevator is now used to detach the mucous membrane from the jaw. The use of this instrument may be supplemented by the surgeon's forefinger.

The spine of Spix is sought for and must be clearly defined. The periosteum must not be detached with the mucous membrane. When the spine of bone is reached the internal lateral ligament may be divided with fine straight iris scissors, the utmost caution being used.

The nerve should now be brought into view and be drawn forwards gently with a small blunt hook (Fig. 61). Long-bladed dissecting forceps are required in this stage of the operation. The nerve is exposed actually as it is entering the bone. Here the vessels are in close contact with it. A little higher up they are removed from the nerve. The inferior dental should therefore be exposed to the extent of about half an inch, and be divided with iris scissors high up. It may be possible to have entirely isolated the nerve upon the blunt hook, which is of very small size. If the operator proceed too far above the dental foramen he will come in contact with the internal maxillary artery. From a quarter to half of an inch of the cord can be excised. The higher section of the nerve is made first. No sutures are required for the wound.

Comment.—This operation is very difficult and very tedious. It is not so readily performed as is the procedure for the removal of Meckel's ganglion. The great depth of the wound, the narrowed space and the embarrassing incidents which are apt to attend operations within the mouth, all contribute to the difficulties of the position. The gustatory nerve may be mistaken for the inferior dental if the dental

foramen be not clearly made out. It may be damaged also during the operation.

Much bleeding may follow the common accident of dividing the inferior dental artery. In one case (Dr. Weir of New York, *Annals of Surgery*, June, 1887) the hæmorrhage

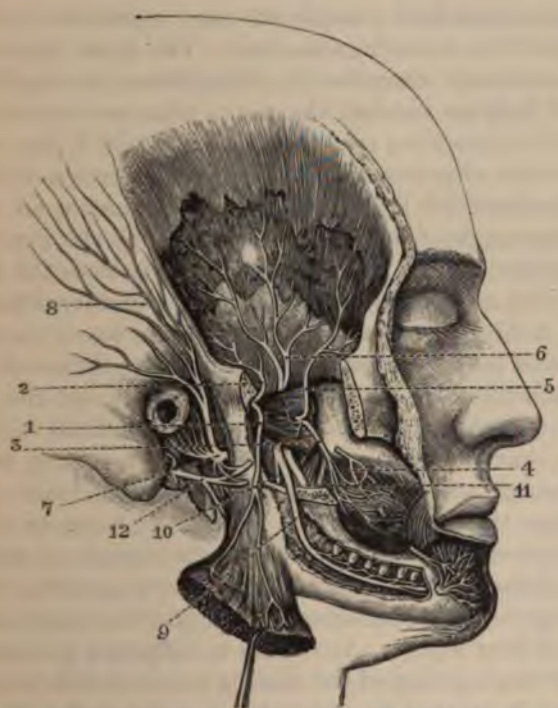

Fig. 66.—THE THIRD DIVISION OF THE FIFTH NERVE. (*After Hirschfeld and Leveillé.*)

1, Masseteric nerve; 2, Posterior temporal nerve; 3, Buccal nerve; 4, Branch to facial nerve; 5, Anterior temporal nerve; 6, Middle temporal nerve; 7, Auriculo-temporal nerve; 8, Its temporal branches; 9, Inferior dental nerve; 10, Mylo-hyoid nerve; 11, Gustatory nerve; 12, Facial nerve.

was very free and was supposed to come from the internal maxillary. The nerve may be ruptured during the process of exposure by being roughly drawn upon.

More constitutional disturbance will usually follow this operation than will attend the operation for the removal of Meckel's ganglion. This has been so in the two cases in which

I have performed both operations (at different periods) upon the same patient. The fauces are swollen, the jaw is stiff, the tongue is swollen, and the whole face aches. The mouth must be kept constantly washed with an antiseptic solution (*e.g.*, carbolic acid lotion, 1 in 60 or 80).

Other Modes of Operating:—

Other operations employed are concerned with the exposure of the nerve from the face. The more important of them are briefly described by MacCormac in the following words: "Velpeau reached the nerve from an opening made through the ascending ramus of the jaw, while Kühn exposed it from below after resecting a portion of the angle of the jaw. Lücke has modified Kühn's operation. He makes an incision around the angle of the jaw corresponding to the insertion of the masseter muscle, raises the soft parts from the internal surface with an elevator, until the inferior dental nerve, and in front of it the lingual, can be felt with the finger; a hook is then passed round the nerve just as it enters the canal.

"If the nerve is to be reached directly through the inferior maxilla (which is an easy and direct method) a curved incision, convex downwards, about two inches long, must be made through the masseter muscle down to the bone.

"When this is exposed the periosteum must be raised so that the central portion of the ascending ramus is laid bare, and the detached soft parts are then drawn upwards. In this way the parotid gland, Stenson's duct, and the facial nerve, are preserved from injury. According to Velpeau's procedure the bone over the opening of the canal is removed with a trephine. We must remember in using this instrument that the jaw is much thicker below than above; and hence the trephine should be laid aside when the upper part of the jaw has been divided, and the rest of the circle of bone must be detached by means of the elevator and chisel. If care be not taken, the artery as well as the nerve may be cut through during the operation, and the bleeding is sometimes very severe. Linhart makes a vertical incision through the masseter for its whole length, and detaches it on each side from the bone, together with the periosteum; he then cuts away the external table of the bone with a chisel, and thus exposes the canal for the space of half an inch, and resects the nerve.

"The nerve may be likewise exposed by cutting out a **V**- or **U**-shaped piece of the ascending ramus of the maxillary bone, the base of the excised portion of the bone being at the coronoid notch, and the apex a little below the opening of the inferior dental canal. The coronoid process can be easily felt from within the mouth when the jaw is depressed. Its position determined, a vertical incision, two inches long, must be made through the integuments over the middle of the ascending ramus of the jaw, the masseter is sufficiently dissected from its attachment to the ramus, and the periosteum is detached with it.

"The necessary amount of bone may then be removed with the chisel, or by means of a cylindrical drill, half an inch in length and the same in diameter, inserted into the mandril of a powerful surgical engine. By it, in revolutions to the extent of 5,000 times in a minute, the nerve is quickly laid bare at its place of entrance in the inferior dental foramen. Next, the opening is enlarged until the internal pterygoid muscle is fairly exposed to view; the nerve is cut below, lifted from its bed, and, while held on the stretch, may be isolated up to the point of emergence at the base of the skull by the handle of a scalpel. Finally, it is excised with a pair of delicate iris scissors."

Comment.—These operations are more easily accomplished by the surgeon, but are of greater gravity to the patient, and in no instance can the difficulty which attends the intrabuccal operation be made an excuse for selecting one of these more serious procedures.

These operations could only be justifiable when, for one or other reason, the exposure of the nerve through the mouth is impracticable.

3. **The Gustatory Nerve.**

Anatomy.—The gustatory nerve is internal and anterior to the inferior dental, and lies between the internal pterygoid muscle and the internal lateral ligament. It is curved, with its concavity forwards, and lies quite superficially between the level of the last molar and the angle of the jaw (Figs. 66 and 67).

Operation.—The mouth having been opened and the cheek drawn aside as in the previous operation, the tongue is drawn forwards and towards the opposite side.

With the fore-finger the surgeon can define the ramus of the jaw and the pterygo-maxillary ligament. The nerve can usually be felt beneath the mucous membrane behind the last-named ligament, and about half an inch behind and below the last molar tooth.

A vertical incision, about an inch in length, is made through the mucous membrane over the nerve, and therefore midway between the tongue and the gum, and at the level of the last molar.

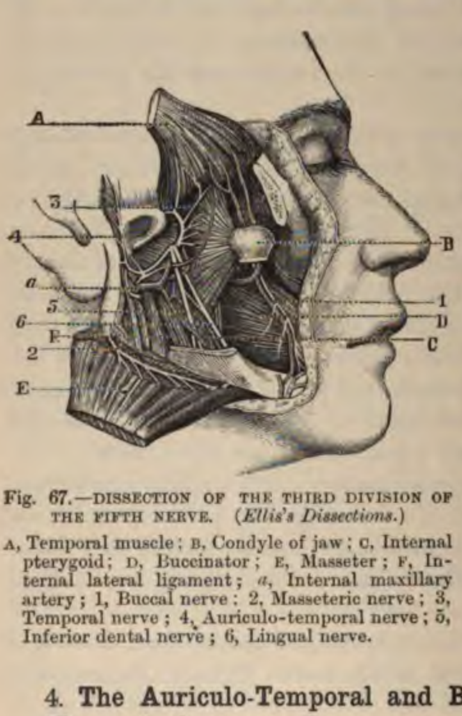

Fig. 67.—DISSECTION OF THE THIRD DIVISION OF THE FIFTH NERVE. (*Ellis's Dissections.*)

A, Temporal muscle; B, Condyle of jaw; C, Internal pterygoid; D, Buccinator; E, Masseter; F, Internal lateral ligament; *a*, Internal maxillary artery; 1, Buccal nerve; 2, Masseteric nerve; 3, Temporal nerve; 4, Auriculo-temporal nerve; 5, Inferior dental nerve; 6, Lingual nerve.

The nerve is exposed, is drawn forwards by means of a small blunt hook (Fig. 61), and some half-inch is excised.

Comment. — Section of this nerve is frequently carried out to relieve the pain and the watering of the mouth in cancer of the tongue. The nerve may be conveniently divided in the neck at the same time that the lingual artery is being exposed for ligature.

4. The Auriculo-Temporal and Buccal Nerves.

The auriculo-temporal nerve may be exposed by a short vertical incision as it crosses the base of the zygoma, immediately in front of the pinna (Fig. 63). The nerve is here in close association with the superficial temporal artery, behind which it is placed. The nerve is hardly free of the parotid gland at the place indicated.

Of the buccal nerve, MacCormac writes: "The buccal nerve may be found from within the mouth, opposite the middle of the anterior margin of the ascending ramus of the lower jaw. If the mucous membrane and fibres of the

buccinator be here vertically divided and the tissues separated with a director, the nerve will be exposed." This operation must be, however, somewhat uncertain. The nerve on reaching the surface of the buccinator muscle at once breaks up into a number of fine branches. Some of these go to the mucous membrane of the mouth; others form a kind of plexus on the cheek, supply the skin, and effect a communication with the facial nerve. The buccal nerve can hardly be regarded as a single well-defined trunk after it has come into relation with the buccinator muscle. A small artery accompanies the nerve.

THE GASSERIAN GANGLION.

The gasserian ganglion has been removed by Mr. William Rose in two cases of intractable neuralgia (*Lancet*, Nov. 1, 1890, and Feb. 7, 1891). In the first case the eye suppurated and was excised. The operation in the second case is thus described: The patient was a female aged sixty, who had suffered for many years from severe neuralgia, affecting chiefly the superior maxillary nerve on the right side. Chloroform was given, and after stitching the eyelids together on that side in order to avoid any accidental injury to the eye, a flap of skin was dissected forward, the zygoma was exposed, and, after openings had been drilled with an electro-motor, divided and drawn down with the masseter muscle. The coronoid process of the lower jaw was next drilled and divided in a similar manner, and turned up with the temporal muscle attached. The external pterygoid muscle was then cut through, and the foramen ovale reached, into which the pin of a half-inch trephine was inserted, and a disc of bone surrounding it in this way removed. The bleeding was troublesome, and persisted for some time. The ganglion was seized by some specially constructed hooks, one of which had a cutting edge upon its concave surface; by means of these its attachments were loosened and divided. Perchloride of mercury solution (1 in 3,000) was used during the operation. The bones which had been sawn were replaced and secured in position by wire sutures passed through the drill-holes previously made, and a drainage-tube inserted. Cyanide gauze dressing was applied. The electric illuminator was found most useful during the

An inch lower down than the occipitalis major, and under the complexus, is the external branch of the posterior division of the third cervical to the splenius. When found, it is to be divided close to the bifurcation of the main trunk. This divides the *third cervical.*

The superficial cervical artery and vein cross the plexus transversely about its middle, and must be carefully sought for and protected. If the finger be passed along the plexus to the interval between the anterior and middle scalene muscles there is no difficulty in identifying any particular cord.

BRANCHES OF THE CERVICAL PLEXUS.

The sensory branches of this plexus are readily reached by an incision about one and a half or two inches in length, which is placed over the posterior border of the sterno-mastoid muscle and at such a height in the posterior triangle that the centre of the incision will correspond to the centre ot the muscle.

The position of the chief superficial nerves of the neck may be fairly indicated by six lines all drawn from the centre of the posterior margin of the sterno-mastoid.

A line drawn forwards from this spot so as to cross the sterno-mastoid at right angles to its long axis, corresponds to the superficial cervical nerve. A second line drawn upwards across the muscle to the back of the pinna, so as to run parallel with the external jugular vein, corresponds to the great auricular nerve; and a third line, running along the posterior border of the sterno-mastoid muscle to the scalp, marks the course of the small occipital nerve. These lines, continued downwards, so as to cross the sternum, the middle of the clavicle, and the acromion, will indicate respectively the supra-sternal, supra-clavicular, and supra-acromial nerves.

THE SPINAL ACCESSORY NERVE.

Stretching, neurotomy, and neurectomy of this nerve have been performed for the relief of spasmodic torticollis of an intractable form. The first two operations have been attended only by temporary relief, the last named with a very fair degree of success.

Anatomy.—The spinal section of the nerve leaves the foramen lacerum posterius with the pneumo-gastric, and in the same sheath with it. It then passes downwards and backwards across the front of the internal jugular vein and

flexor carpi ulnaris, and runs under cover of that muscle a straight course to the wrist.

In the upper two-thirds of the forearm it is deeply placed; but in the lower third it is superficial, having the tendon of the flexor carpi ulnaris on its inner side and the ulnar artery on its outer side. It crosses the anterior annular ligament between the pisiform bone and the ulnar artery.

The dorsal branch to the hand leaves the trunk some two or three inches above the wrist.

At the elbow the nerve has been found passing in front of the internal condyle.

Operations.—(*a*) Above the centre of the arm the nerve may be exposed by an incision parallel to the line of the brachial artery and half an inch to the inner side of it. In exposing the nerve care must be taken to avoid injury to the venæ comites of the brachial artery, the nerve of Wrisberg, and the ulnar collateral nerve, all of which are in near association with the trunk sought for.

(*b*) The ulnar nerve is very conveniently exposed just above the internal condyle. The incision should be about one inch and three-quarters in length and should lie upon the line for the nerve already given. The cut should extend to within about half an inch of the internal condyle. The nerve is found to lie along the back of the internal inter-muscular septum with the inferior profunda artery which is placed to its outer side.

(*c*) Just above the wrist the nerve may be exposed by means of an incision one inch and a half long made parallel to the tendon of the flexor carpi ulnaris and just to its outer side. After the integuments and fascia have been divided the nerve is brought at once into view, the artery lying to its radial side.

3. THE MUSCULO-SPIRAL NERVE.

Anatomy.—Commencing behind the axillary vessels this nerve runs backwards into the musculo-spiral groove, accompanied by the superior profunda artery; on reaching the outer side of the limb it pierces the external inter-muscular septum about midway between the insertion of the deltoid and the tip of the external condyle, and descending between the supinator longus and the brachialis anticus divides about the level of

CHAPTER III.

Operations upon the Nerves of the Upper Extremity.

1. THE MEDIAN NERVE.

Anatomy. — This nerve is superficially placed in the arm and at the wrist, but has a deep course in the forearm. In the arm, it is in close relation with the brachial artery, lying to its outer side above, crossing it about the middle of its course, and lying to its inner side at the bend of the elbow. In the forearm the median lies in the middle of the limb, between the deep and superficial flexors of the fingers. At the wrist it can easily be made out between the tendons of the flexor carpi radialis and the palmaris longus.

Operations.—(*a*) In the arm the nerve can be exposed through such an incision as is employed to secure the brachial artery, *e.g.*, in the middle of the arm (page 126).

(*b*) At the wrist it is readily exposed through an incision about one inch and a half in length which is parallel with the tendon of the flexor carpi radialis and close to its ulnar side. A superficial vein or so may be cut, the fascia is divided and the nerve can at once be brought into view.

2. THE ULNAR NERVE.

Anatomy.—The ulnar nerve is superficial in the arm, being covered only by the skin and fascia. It follows at first the line of the brachial artery, lying to the inner side of that vessel. It is then represented by a line drawn from the inner side of the artery about the level of the insertion of the coraco-brachialis to the gap between the inner condyle and the olecranon. In this latter part of its course in the arm it is accompanied by the inferior profunda artery, which lies to its outer side. It passes between the two heads of the

CHAPTER IV.

OPERATIONS UPON THE NERVES OF THE LOWER EXTREMITY.

1. THE GREAT SCIATIC NERVE.

Anatomy. — This, the largest nerve in the body, extends from the lower border of the pyriformis muscle to a point a little below the middle of the thigh, where it separates into its two divisions, internal and external popliteal.

It rests upon the external rotators of the hip and upon the adductor magnus. It is covered behind by the gluteus maximus and the hamstring muscles.

It lies in the hollow between the great trochanter and the tuber ischii, being a little nearer to the latter than to the former process of bone. The small sciatic nerve lies in the same line as the great cord but superficial to it. The comes nervi ischiadici accompanies the great sciatic.

The bifurcation of the nerve may take place at any point between the sacral plexus and the lower third of the thigh.

The "fold of the buttock" is considerably above the level of the lower border of the gluteus maximus, with which therefore it does not correspond. When the hip is fully extended, as in the erect posture, the buttocks are round and prominent, the gluteal fold is transverse and very distinct. When the hip is a little flexed, the buttocks become flattened, the gluteal fold becomes oblique and to a large extent disappears.

Operation.—The nerve is most accessible for stretching if exposed at the lower border of the gluteus maximus muscle, just as it is leaving the hollow between the tuber ischii and the great trochanter. This corresponds to its most superficial part.

The patient should be turned sufficiently over upon the face to enable the buttock to be exposed and the thigh to be

extended. A vertical incision, four inches in length, is then made in the course of the nerve.

The incision should commence over the gluteal fold, and should be exactly opposite to the middle of the interval between the tuber ischii and the great trochanter. If the wound be made nearer to the tuber there is an increased difficulty in displacing the hamstring muscles.

The centre of the incision will about correspond to the free lower margin of the gluteus maximus.

The skin and fascia having been divided, the small sciatic nerve and a few cutaneous arteries will be encountered. The quantity of the subcutaneous fat may be considerable.

The lower border of the gluteus maximus should be clearly exposed as it runs obliquely downwards and outwards.

The edge of this muscle must be drawn upwards by means of a strong and somewhat broad retractor.

The finger introduced into the wound will now encounter the hamstring muscles a little below their origin from the tuber ischii. These muscles should all be drawn inwards, their fibres having been first relaxed by bending the knee. They are retained in position by another strong and broad retractor.

The nerve should now be readily discovered and brought into view.

2. THE INTERNAL POPLITEAL NERVE.

This nerve, the larger of the two divisions of the great sciatic, continues the direction of the main trunk, passes through the middle of the popliteal space, and at the lower margin of the popliteus muscle ends as the posterior tibial nerve.

The internal popliteal can be very conveniently reached through the incision made for ligaturing the lower part of the popliteal artery (page 186).

3. THE EXTERNAL POPLITEAL NERVE.

Anatomy.—The external popliteal or peroneal nerve follows the outer side of the popliteal space, lying close to the biceps. Passing over the outer head of the gastrocnemius, between it and the biceps, the nerve reaches the neck of the fibula, and

crosses that bone beneath the fibres of the peroneus longus muscle.

The nerve may be easily felt, when the knee is a little flexed, as a loose rounded cord, lying just behind the biceps tendon, as it nears the head of the fibula.

Operation.—The patient lies upon the sound side with a sufficient tending to the prone position to well expose the outer aspect of the knee.

The knee-joint is extended. An incision, one inch and a half in length, is made parallel with and immediately posterior to the tendon of the biceps. The cut should be so placed that its upper half is in relation with the tendon while its lower half is over the fibula. The skin and deep fascia having been divided the biceps tendon is exposed.

The knee should now be a little flexed and the nerve sought, close to the point at which the tendon reaches the head of the fibula.

A narrow and unduly prominent ilio-tibial band has been mistaken for the biceps tendon.

4. THE ANTERIOR CRURAL NERVE.

This large nerve descends into the thigh in the groove between the psoas and iliacus muscles, and almost immediately below Poupart's ligament becomes flattened out and breaks up into numerous branches. The nerve is separated from the artery by the psoas muscle.

A vertical incision, two inches in length, should be made in the course of the nerve, and should commence a little above Poupart's ligament. In the superficial tissues of the region the crural branch of the genito-crural may be met with and the superficial circumflex iliac vessels will cross the line of the wound. The fascia lata having been divided and the hip a little flexed, so as to relax the muscles, the nerve will be found without difficulty. The edge of the sartorius muscle need not be exposed.

5. THE INTERNAL SAPHENOUS NERVE.

Anatomy.—This nerve can be most conveniently reached at the inner side of the knee opposite to the inner tuberosity of the tibia. When the long saphenous nerve leaves the

noral vessels it passes beneath the sartorius to the inner le of the knee, accompanied by the superficial branch of the astomotica magna artery. Near the inner condyle of the nur the nerve gives off its patellar branch, which becomes taneous by piercing the fascia in front of the internal phenous vein. The trunk becomes superficial opposite to e tibial tuberosity by piercing the fascia at the posterior rder of the sartorius.

Operation.—An incision, about one inch and a half in igth, made along the posterior margin of the sartorius posite to the tuberosity of the tibia, should bring the nerve to view.

The vein is an excellent guide to it, and as a rule the nerve ll be found to be just posterior to the vein.

If the incision be made higher up, the patellar branch of e nerve—which lies in front of the vein—may be mistaken r the main trunk.

At the site of the operation some cutaneous arteries derived om the anastomotic will usually be found with the nerve.

The nerve is quite superficial at this point.

The vein when exposed should be gently drawn inwards.

Part V.

AMPUTATIONS.

GENERAL CONSIDERATIONS.

CHAPTER I.

THE HISTORY OF THE OPERATION.

THE slow development of methods for amputating limbs is one of the most remarkable features in the history of surgery.

The conspicuous part which amputations play in practice, and the prominent position they assume among surgical operations, render this circumstance especially noteworthy.

The removal of a limb by what may be termed a reasonable operation is a matter belonging only to comparatively recent times, and the majority of the procedures now in use can claim no greater antiquity than pertains to the last century or to the present.

For some hundreds of years amputation, so called, was limited merely to the removal of gangrenous limbs by cutting through the dead part.

The difficulty in the way of the development of the operation was the ignorance of any certain means of controlling and arresting hæmorrhage.

It is from the time of the introduction of ligatures for bleeding vessels and the invention of the tourniquet that the operation of amputation may be considered to date.

Hippocrates, "the Father of Medicine," who flourished some four hundred years before the Christian era, had no conception of amputation of a limb as a surgical procedure.

The matter is alluded to in his account of gangrene of the extremities. "Those parts of the body," he writes, "which are below the boundaries of the blackening are to be removed

only be termed barbarous. Limbs were removed by means of the chisel and mallet, the operation in the case of the hand being accomplished by one blow. The very powerful shears invented by Botal, of Asti, were in use, and it was claimed for them also that they could effect the removal of a limb by a single cut. Sickle-shaped and curved knives were employed, and, indeed, it was not until late in the eighteenth century that the straight blade was introduced.

John Woodall (1617) was the first surgeon to advise amputation of the leg as low as the ankle in diseases and injuries of the foot.

The invention of the tourniquet, gripe-stick, garrot, or Spanish windlass, is ascribed by some to the French surgeon Morel (1674), and by others to Young, of Plymouth (1679).

The somewhat rude contrivances at first introduced were rapidly improved, and the operation of amputation became, in consequence, much simplified.

The later history of amputation is very admirably summarised by Ashhurst ("Encyclopædia of Surgery," vol. i.) in the following words:—

"As soon as surgeons had begun to emancipate themselves from the Hippocratic and Galenic doctrine of cutting only dead tissues, it was natural that they should adopt the Celsian method, and we accordingly find that the circular mode of amputation was practised at an earlier period than any of the flap operations.

"The first important modification introduced into the procedure of Celsus was the suggestion, about the same time and apparently independently of each other, by Petit in France, and by Cheselden in England (1749), of the double incision of the soft parts: the skin and superficial fascia being divided first, and retracted, and the muscles cut by a second incision at the highest point thus exposed. . . . .

"Louis practically returned to the Celsian method, dividing all the soft parts at the same level, but sawing the bone at a higher point—an important feature of the operation, the value of which Petit and Cheselden had overlooked. Louis also employed digital compression instead of the tourniquet, believing that the latter interfered with the retraction of the muscle.

"Valentin (1772) advised that the position of the limb should be varied at different stages of the operation, so that the muscles of each part should be left as long as possible.

"With a similar view, Hey, of Leeds, in amputating the thigh, divided the posterior muscles at a lower level than the anterior, in order that their greater tendency to retraction might thus be compensated for.

"To this surgeon, together with Allanson, of Liverpool, and Benjamin Bell, of Edinburgh, is due the improvement by which a sufficient covering was secured for the stump by dissecting up the skin and fascia so as to form a cuff, which was afterwards brought down over the muscles and bone. . . . . When the limb was a large one, Desault divided the muscles in two layers; he also divided the skin by two semi-circular incisions, instead of making one complete circle, but, like Petit, he divided the bone on a level with the highest section of the muscles.

"The operation of Bell and Hey—that 'with the triple incision,' as the latter called it, the skin and fascia being first divided and dissected up for a sufficient distance, then the muscle cut and separated from the bone, and this finally sawn through at a still higher point—constitutes in all essential particulars the circular operation of the present day.

"The first flap-operation appears to have been suggested by Lowdham, of Exeter, as described by Young, of Plymouth, in his "Currus triumphalis e terebintho," published in 1679. . . . . Lowdham's and Young's operation was applied to the leg, and consisted in cutting from without inwards a long flap of skin and fascia from over the muscles of the calf.

"Verduin, of Amsterdam, in 1696, and Sabourin, of Geneva, in 1702, introduced the plan of forming a musculo-cutaneous flap from the calf of the leg, by transfixion, and attempted to control the bleeding by pressing this firmly against the end of the stump. Verduin's flap was adopted by Garengeot, who, however, ligatured the bleeding vessels, and thus perfected the ordinary flap operation of the leg as it is still often practised at the present day.

"O'Halloran (1764), an Irish surgeon, likewise employed this mode of amputation, but did not close the stump till the flap was already covered with granulations.

"The earliest double-flap amputation . . . . appears to have been practised by Ravaton, a French surgeon, about the year 1739. He applied this method of operating to the thigh, making first a circular incision down to the bone, and supplementing this by longitudinal incisions in front and behind, making thus two square, muscular, lateral flaps, at point of junction of which the bone was then divided.

"Vermale modified and improved this procedure by making the flaps of a rounded or somewhat oval shape, and by forming them by transfixing the limb with a long knife and cutting from within outwards. . . . . The flap operation, in one or other of its forms, was soon adopted by other surgeons, and with various modifications was finally brought into ordinary use through the example mainly of Liston and Guthrie in England, of Dupuytren, Roux, and Larrey, in France, and of Klein and Langenbeck in Germany. All the various forms of amputation which have been since employed may be regarded as varieties of these two principal methods, the flap and the circular."

The introduction of anæsthetics has materially altered the details of amputation as an operative procedure. In the days before chloroform, the principal good quality which commended itself both in the method and in the operator was rapidity of execution. Time was an essential element in every amputation. The capacity of a surgeon was apt to be gauged more by the minutes he required for the removal of a leg than by the character of the stump which resulted from the operation.

It thus happened that the cutting of flaps by transfixion, and the selection of sites suited for this method, were prominent features in the science and art of amputation as taught immediately before the introduction of anæsthetics.

In dealing with a diseased foot it was considered advisable to amputate the leg at the place of election, for the two conspicuous reasons that the operation could be very rapidly performed, and as the patient would for the future bear pressure upon the bent knee, the condition of the stump was of small moment. An operation such as Syme's amputation would have involved time, and would have required considerable deliberation, and its success would have involved the capacity of the stump for bearing direct pressure.

Amputations were planned with comparatively little care. The limb had to be "whipped off" while the patient was conscious, and the method that permitted of its most ready execution was the best.

Now that time is of comparatively little consequence in the majority of cases, the whole aspect of amputation methods has been altered. The flaps can be cut with great accuracy and deliberation, and the procedure carried out with the precision of a plastic operation.

It has been made evident that a limb may be more conveniently removed by cutting in a steady manner, and upon minutely defined lines, than by slashing it off by a few brilliant and momentary passes of the knife.

The introduction of anæsthetics has rendered possible such admirable operations as Farabeuf's amputation by an external flap at the place of election, the subastragaloid amputations, and the various osteo-plastic methods of removing diseased parts.

The very character of the instruments used in amputation has been altered. The long slender flashing blade of Fergusson's time is now but seldom seen. (Fig. 97.) Many amputations are now best effected simply with a large scalpel.

The great amputating-saw that in skilled hands would divide the femur in so many feverish cuts, is replaced by an instrument which cuts more slowly, but at the same time more accurately and more neatly.

The improved methods of treating wounds and of securing bleeding points have also had much influence upon the development of the operation. Many procedures which now yield admirable results would have been almost unjustifiable at a time when wounds were adjusted with hempen sutures, and dressed with rags soaked in oil.

No one single factor conduces more to the production of a perfect stump than healing by primary intention, or the closure of the incision without suppuration.

CHAPTER II.

The Amputation Stump.

The success of any amputation or method of amputating is to be measured not by the rapidity or brilliancy with which the operation is performed, but rather by the mortality attending the procedure, and the qualities of the resulting stump.

The importance of a sound stump, both as far as it relates to the comfort of the patient and the utility of the mutilated limb, cannot be over-estimated.

1. **A good stump** is of regular outline, firm, solid, and insensitive. The scar is narrow, regular, and clean, and lies in a groove in the integuments (Figs. 102 and 127).

The *skin* is mobile, except at the site of the cicatrix, is well nourished, and capable of resisting pressure. Those stumps are the best, so far as the integumentary coverings are concerned, in which the skin over the more exposed parts is normally accustomed to pressure. Such stumps are illustrated by those in which the principal flap is derived from the sole of the foot, the heel, the palm of the hand, the front of the knee, the back of the elbow.

The *muscles* become atrophied, and their divided extremities are found to be embedded in a mass of sound fibrous tissue. Those whose functions are abolished are more or less entirely converted, in process of time, into connective tissue. Such as retain any capacity for action, retain to a corresponding extent some muscular structure.

The divided *bone* becomes rounded off, the medullary canal is closed either by bone or by fibrous tissue. The extremity becomes either atrophied and pointed, or presents an abnormal enlargement due to a development of bone from the periosteum.

The new bone in some stumps forms a button or mush-

room-like extremity for the shaft. In other instances the new bone formations are scanty and spicular, and play the part of foreign bodies in the stump.

The whole shaft of the bone wastes. After an amputation through the knee, the femoral condyles may entirely disappear, and in an amputation above that joint, not only may the shaft and tuberosities become evenly atrophied, but this retrogressive change may extend to the pelvic bones of the same side.

After a disarticulation the *cartilage* left upon the bone atrophies, and becomes fibrous, or entirely disappears in the course of years.

The *nerves* undergo a like atrophic process. The true nerve fibres disappear to a variable extent, and are replaced by connective tissue. This change may extend to the spinal cord, and even to the nerve columns concerned.

The divided extremities of the nerves may become enlarged and form considerable bulbous terminations. It may be here said, however, that this condition is not necessarily associated with tenderness of the stump (*see* page 268).

The *collateral circulation* is soon restored in the limb after the high division of the main artery. That trunk in time attains to such dimensions as are demanded by the vascular needs of the part. Some years after an amputation at the hip by an anterior flap, the portion of the femoral artery left in the stump will probably be no larger than the radial.

The wasting of the main trunk may be attended by an over-development of certain of its branches, so that after a lapse of time the principal artery may be difficult to identify on dissection.

2. **The bad stump** may owe its evil properties to many conditions. An amputation wound is liable to all the ills and misfortunes which may attend the progress of any other extensive incision.

In dealing with this point it is necessary to exclude those diseases of stumps which depend upon an extension or a reappearance of the original malady.

The skin may be scanty, thin, tightly drawn, unduly and unevenly puckered and adherent. The vitality of the integument may be so debased that the stump remains cold and purple, and liable to ulcerative changes which pathologically

are allied to chilblains, and the superficial gangrenous processes incident to the senile.

On the other hand, ulceration of a stump may appear to be due to such gross trophic changes that they are rather to be compared to the bedsores of the paralysed, or the "perforating ulcers" of locomotor ataxia.

The scar may remain weak, or become eczematous, or be, on the other hand, excessive, or take on the development of warty growths. The chronically inflamed and irritated cicatrix may become in time the seat of an epithelioma.

On the skin may form corns or under it may develop bursæ.

The end of the divided bone may necrose, or the shaft may become inflamed.

The stump may be excessively tender, and the seat of continued pain. In some instances the pain is due to a slowly progressing periostitis or osteitis. In the greater number of examples it depends upon the compression of a nerve.

The nerve may be stretched over the extremity of the stump, or be exposed directly to pressure, or be the seat of actual neuritis. Its divided end may be compressed by the contraction of the mass of fibrous tissue in which it is embedded, or be irritated by a spicule or projecting mass of new bone.

On examining *painful stumps* by dissection it is common to find the ends of the divided nerves bulbous. There would however appear to be no essential or constant relation between pain in the stump and a bulbous enlargement of the nerve ends. Such enlargements may be found in stumps which are insensitive and capable of bearing any reasonable amount of pressure, and may be absent in cases of painful stump.

The examples of painful stump of less clear origin are ascribed to neuralgia when the patient is a male, and to hysteria when the patient is of the opposite sex.

One of the most common and most troublesome of bad stumps is that known as the conical stump.

3. **The Conical Stump**, or sugar-loaf stump, requires no description. The apex of the cone is formed by the extremity of the bone, which is not infrequently exposed and dead. The real conical outline is best seen in bad stumps following

amputation through the arm or thigh, but all ill-covered stumps, such for instance, as may be left after disarticulation at the knee or elbow, must be placed in the present category, although they cannot assume the typical outline (Fig. 68).

The following are the usual *causes of the conical stump*:—

(*a*) Too short flaps or too low division of the bone, whereby the soft parts when adjusted prove to be so scanty that the stump may be considered to be conical from the commencement.

Fig. 68.—CONICAL STUMP FOLLOWING CIRCULAR AMPUTATION OF THE THIGH AND DUE TO RETRACTION OF THE POSTERIOR AND INTERNAL MUSCLES. (*Farabeuf.*)

(*b*) The more or less extensive sloughing of the flap or the loss of a considerable portion of the soft parts by suppuration.

(*c*) The retraction of the muscles after the amputation has been completed. This retraction is a very common cause of conicity. A stump which at the time of the operation looked round and substantial may, as a result of slow and progressive retraction, become in time quite cone-shaped and useless.

This condition is most usually met with in amputation through very muscular parts and in muscular subjects. It is common in the thigh and upper arm, and in the leg. In the latter situation it is due to the unequal and excessive contraction of the great muscles of the calf. (*See* also page 271.)

Rapid healing of the wound is the main opponent of secondary retraction of muscle. In most conical stumps the healing has been slow and ill-conditioned.

(*d*) Growth of the bone in young subjects. After an amputation it would appear that action ceases in the epiphyses left in the stump. The bone does not continue to grow at the same rate as the corresponding bone on the opposite side. The main stimulus to the epiphysis is removed.

To this rule, however, there are exceptions. Now and then the epiphysis appears to be at least normally if not

unduly active after amputation. The shaft left in the stump grows, the bone in time tends to protrude, and a conical stump is produced. This condition is most often met with after amputations through the arm in quite young subjects. Growth does not cease at the upper end of the humerus until about the twentieth year. The following example illustrates this unusual form of conical stump: In the case of a boy, aged nine, I amputated the left arm, for injury, dividing the bone just above the insertion of the deltoid muscle. The wound healed without complication. So active, however, was the growth in the upper epiphysis of the humerus that before the lad reached the age of seventeen years the stump had become conical three times, and on three occasions I had to saw off a not inconsiderable portion of the shaft of the bone, to restore the proper outline of the stump.

A similar cause of conical stump has been observed in amputations of the leg close to the knee joint. The epiphyses unduly active in such a case belong to the lower end of the femur and the upper ends of the tibia and fibula. In these parts of the bones growth does not normally cease until about the twenty-first year; while the upper epiphysis of the fibula does not join the shaft until the twenty-fourth year.

4. Circumstances affecting the Contraction of the Stump Tissues.

In planning the flaps for an amputation it is of the first importance that attention be paid to the normal contractility of the component skin and muscles.

(*a*) *The skin.* The contractility of the skin is considerable, but subject to much variation. It is practically lost in parts which have been long distended or long infiltrated. This is well seen in the integuments about a white swelling of a joint or a chronically inflamed part. The skin is apt to be loose in the aged and in those who have become rapidly thin, but at the same time it is found to have lost more or less entirely its retractile qualities.

It is needless also to point out the loss of contractility in skin which has become much atrophied or which has been long adherent to the deeper parts.

Other things being equal, the skin is most contractile in regions where it is thin, where the subcutaneous tissue is

scanty in amount, where the integuments are not normally connected with deep aponeuroses or points of bone, and where it is but little stretched in any position of the limb. These regions are illustrated by the dorsal aspect of the wrist, the front of the bend of the elbow, the front of the forearm and arm, the district just above the ankle, and the region of the popliteal space.

Contractility is, on the other hand, least marked in parts where the skin is thick, where the subcutaneous tissues are considerable, where the soft parts are connected with deep fasciæ or points of bone, and where the integument is exposed to stretching in certain postures of the limb.

These regions are illustrated by the palm of the hand and the sole of the foot, by the dorsal aspect of the finger joints, by the soft parts in front of the knee and behind the elbow, and by districts in which the deposit of subcutaneous fat is considerable.

Speaking in general terms, the average contractility of the skin may be represented by one-third of the length of any given portion, that is to say, if a skin flap is required to be 8 c.m. in length in order to cover the bone, its length before its separation should be 12 c.m.

(*b*) *The Muscles.*—All muscles, of course, contract on division, but the extent of that contraction is subject to remarkable variations.

Those muscles retract most which are quite free between their points of origin and insertion, and which are provided with long fibres, such as the sartorius, gracilis, and the biceps humeri.

These muscles may lose, according to Farabeuf, as much as four-fifths of their length on division.

Those muscles contract least which are provided with short fibres, as illustrated by the penniform and bipenniform muscles—which are connected with bone at the seat of the division, as is the brachialis anticus, or which are attached to aponeuroses—as illustrated by the flexor muscles of the forearm just below the elbow joint.

In a circular amputation at the middle of the arm the different degrees of contractility are well illustrated by the biceps on the one hand and the brachialis anticus and triceps

on the other. An equally forcible comparison is provided in the calf, where the contraction of the surface muscles is measured against that of the deep.

Muscular contraction is influenced also by the size of the muscle, by the amount of it left in the flap, by the age and health of the patient, and the degree of his muscular development.

It is impossible to gauge the contraction which will take place in a young, vigorous, and athletic man by that which is observed when the same muscles are divided in an aged, cachectic, or bed-ridden subject.

Fig. 69. — STUMP OF RIGHT ARM AFTER AMPUTATION BY TWO EQUAL LATERAL FLAPS. THE GREATER RETRACTION OF THE INNER FLAP HAS DRAWN THE CICATRIX TO THE INNER SIDE. (*Farabeuf.*)

The muscles to be divided may have become atrophied, or may be infiltrated with inflammatory material or by a new growth, or may have already become fully contracted from a long continued, fixed position of the limb.

In addition to the immediate contraction of a divided muscle there is also the secondary retraction, which follows slowly. This secondary retraction is of course influenced by the conditions already detailed, but it depends probably to a much greater extent upon the circumstances of the healing process.

Stumps in which, at the time of the operation, a very liberal provision for the covering of the bones was made, may become in time conical, if the healing process be ill-conditioned and much prolonged.

The main preventive of secondary retraction of muscles is rapid and sound healing.

Considering the contractility of all the soft parts together (skin and muscles) Farabeuf lays down the following *rules:*

1. The primary or immediate retraction of the tissues forming a flap may be represented by one-third of the length of that flap, *i.e.*, if a flap of 10 c.m. is required to cover the bone, it should be cut 15 c.m. long.

Additional length must be given to the flap—

(*a*) When the section of the bones is large compared with the section of the soft parts—as in an amputation just above the wrist or through the leg (in a thin subject) a little below the knee-joint.

(*b*) When secondary retraction is to be feared.

(*c*) When the amputation is performed at some distance from the root of the segment of the limb concerned. In such case all the muscles in the flap are cut at little less than full length. Thus, other things being equal, the flaps should be proportionately longer in an amputation just above the wrist than in an amputation just below the elbow, the same muscles being involved in both cases.

2. The integumentary part of the flap should always be longer than the muscular part.

The effects of the retraction of the tissues after operation upon the outline of the wound vary in different parts. Thus a circular incision at the wrist becomes an elliptical incision with the highest point posterior, in consequence of the undue retraction of the dorsal integuments.

A circular wound about the centre of the forearm remains circular, since the parts contract equally.

A circular incision at the elbow becomes elliptical with the highest point anterior, owing to the undue contraction of the soft parts in front of the joint.

A circular wound in the thigh takes an elliptical outline with the highest point postero-internal. It has therefore been said by Marcelin Duval, "To carry out the circular method in the thigh, one must practise the elliptical incision."

The contraction of the tissues of a flap may be very unequal, owing to local changes in the part of the limb involved.

5. **Circumstances affecting the Vitality of the Stump Tissues.**

The vitality of a stump, and as a consequence its disposition to heal, depends mainly upon the character of its blood supply.

If a large fleshy or cutaneous flap be cut containing an insufficient number of uninjured arteries to meet its nutritive needs, it is obvious that no skill in operating, and no care in the after-treatment, can save some portion of the flap at least from destruction.

In fashioning the heel flap in a Syme's amputation at the ankle a very slight deviation of the knife will at once deprive the flap of one-half of its proper blood supply.

In like manner in the amputation at the place of election in the leg by Farabeuf's method, the single external flap is admirably well nourished so long as the artery embedded in it remains intact; but if by any unfortunate movement of the knife the vessel is divided at the last moment at the base of the flap, no skill can save its tissues from some loss by sloughing.

Moreover, a well-nourished flap may be rendered anæmic by the compression of bandages or by its being too tightly fixed to a supporting splint.

The same effects—but in less degree—may follow the bending of the integuments over the bone. Such bending may compress the vessels of the flap to a dangerous degree, especially when the part is much drawn upon by tight sutures.

In considering this effect note must be taken of the natural disposition of the parts. For example, after a disarticulation at the knee-joint by a long anterior flap the skin is in its normal position when it is folded over the femur, and no undue compression of the vessels will occur.

But in a disarticulation at the same place by a single long posterior flap the tissues of that flap are so bent over the condyles of the bone as to cause the contained vessels to be very easily occluded.

Undue traction upon a flap must in almost every amputation tend to diminish its blood supply.

In fashioning skin flaps, care must be taken that they are not too scantily cut, and that the skin itself is not separated from the subcutaneous tissues.

The blood supply of the skin—from the point of view of flap formation—varies in different parts of a limb, and is most efficient in the region of the joints. The largest skin flaps possible in amputation may be cut from the front of the knee or the back of the elbow. Flaps of corresponding size separated from the segments of the limbs above and below these joints would in all probability perish from mal-nutrition.

Long tendons and loose aponeuroses should not be left in

a stump. Their vitality is low, and they show a great disposition to slough.

The bone in the amputation stump not infrequently becomes necrosed. This may be due to rough and rapid sawing, or to extensive damage to the periosteum.

The other circumstances influencing the vitality of flaps are more or less general, and need not be considered in detail.

Among them are the health and condition of the patient, the state of the limb previous to amputation, the manner in which the operation is conducted, and the treatment of the wound carried out.

6. **The Situation of the Cicatrix.**

The utility of a stump depends to no small extent upon the position of the cicatrix. It is important, when possible, that the cicatrix should be so placed as to be the least exposed to pressure.

In this connection it must be borne in mind that the function of a stump in the lower extremity is very different from that of a stump in the upper limb. The former should be capable of withstanding pressure and of bearing weight upon its extremity. The scar therefore will be least well placed when it is "terminal," or situated upon the point or summit of the stump. It will be most conveniently disposed when it is "lateral," or placed upon one of the sides of the stump.

On the other hand, in the upper limb the stump is not required to bear weight or to withstand pressure upon its extremity. The pressure will most usually come upon the sides or circumference of the stump. This is seen in noting the movements of an artificial arm—*e.g.*, after an amputation above the elbow—when the limb is passed in various directions. As the apparatus is placed in one or other attitude the stump which directs it will receive pressure on its "sides," but not upon its extremity or terminal point.

In a general way therefore it may be said that the position of the cicatrix which is best adapted for stumps of the upper limb is least adapted for those of the lower.

Some stumps of course require quite special support and

some artificial limbs can be worked independently of any assistance from the actual stump itself.

If a "peg-leg" be employed after an amputation at the place of election, the position of the cicatrix is a matter of not the least importance.

Amputation cicatrices may be divided into three classes:

(*a*) *Terminal*, when the scar occupies the actual extremity of the stump (Fig. 142).

(*b*) *Lateral*, when it occupies one or more of the sides of the stump or parts of its circumference, as, for example, when the wound is placed upon the anterior, or posterior, or internal surface of the limb (Figs. 102, 127, and 130).

(*c*) *Termino-lateral*, when a terminal cicatrix is prolonged on to one or more of the sides of a stump (Fig. 69).

The position of the cicatrix after amputation by various methods may be detailed as follows. In considering this matter, however, the effects of the retraction of the tissues after operation, upon the outline of the wound, must be borne in mind (page 270).

Circular	=	scar terminal.
Elliptical	=	if oblique, scar wholly lateral; if nearly horizontal, scar terminal.
Oval or racket	=	scar termino-lateral.
Single flap	=	scar lateral.
Double flap	=	if of equal size, scar terminal; if of unequal size, scar lateral.

CHAPTER III.

The Controlling of Hæmorrhage during the Operation.

Under this heading may be considered (A) the use of the tourniquet, (B) the use of Esmarch's band, and (C) the employment of digital compression.

(A) *The tourniquet* has been the subject of almost endless modifications. Originally it took the form of a simple band or fillet, which was tied as tightly as possible around the limb, above the site of the amputation. Then came the invention of Morel (1674), by which sticks were introduced under the band, and twisted round so as to compress the limb as vigorously as required.

Following upon this was the admirable tourniquet of Petit (1718), in the construction of which a metal screw was introduced, and in which the principal pressure was brought to bear upon the main artery.

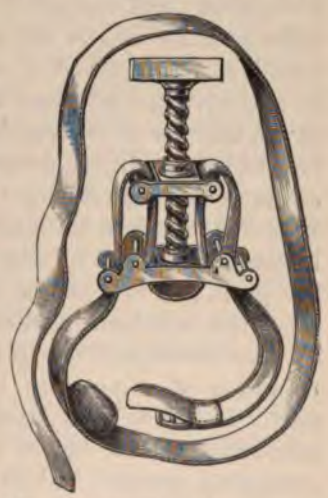

Fig. 70.—Petit's screw tourniquet.

Petit's instrument, and its modifications, represent one type of tourniquet (Fig. 70). The whole of the circumference of the limb is more or less tightly compressed, while localised pressure is brought to bear upon the main vessel. This type of instrument has the advantage of being kept easily in place, and the disadvantage of compressing all the vessels of the limb, especially the veins. It plays the part of a very tightly-tied cord.

The second type of tourniquet is of later development. No band is employed; the whole instrument is of metal, and an attempt is made to limit the compression to the main artery.

Fig. 71.—WEISS'S MODIFICATION OF SIGNORONI'S TOURNIQUET.

This form of apparatus is illustrated by Signoroni's horseshoe tourniquet (Fig. 71), and by the tourniquets of Skey, Lister, and De Carte.

These all possess the advantage of not compressing the entire limb, and of leaving the greater part of the circumference free, but the disadvantage of being very easily displaced and put out of position.

The objections to all tourniquets are these: An apparatus is required; and, indeed, to suit the needs of all cases, many different instruments are necessary. The compression is unintelligently employed, is apt to be irregularly applied, and to be excessive and injurious in amount. During the movements of the limb, or of the patient, the tourniquet is very liable to be displaced. Instruments of the Petit type have the disadvantage of compressing the limb in its entire circumference. However ingenious the pad, or however carefully it is adjusted, it can scarcely avoid compression of the main vein (as in the groin), as well as the main artery. With Petit's instrument this is indeed inevitable.

The tourniquet has played a very important part in the operation of amputation, but its chief merits belong to the past. It is but little used at the present time. It was of admirable service before the days of anæsthetics, when the struggling patient had to be firmly held and the artery to be compressed by main force, and when the means employed for the securing of divided vessels were tedious and uncouth.

(B) *Esmarch's bandage* and tourniquet have enjoyed a high reputation, and have been extensively employed in cases of amputation. The method involved reproduces that of the oldest form of tourniquet—the fillet, with the important

difference that the constricting band is elastic, instead of being unyielding.

That the band is of great convenience to the surgeon is obvious; that it is of material assistance to the hesitating and nervous operator is also evident. Its advantages to the patient, however, are not so clear.

Not a little of the reputation attending the apparatus has depended upon its fortuitous association with the attractive term "bloodless operation."

It has long since been shown that, within limits, the loss of blood at an operation is not the only possible evil, and that a perfect result does not of necessity follow a bloodless method.

The objections to the tube, or band, are these:

In the first place, if the pressure be maintained for more than a quite short time, some temporary paralysis of the vasomotor nerves of the part follows, with the result that when the tourniquet is removed an unusual amount of oozing occurs from the still dilated vessels. General oozing is less easy to deal with than are a few spurting arteries; the after-bleeding may be so considerable that the term "bloodless method" becomes quite *mal-apropos*. Oozing usually involves much sponging, rubbing, and washing of the raw surface, the possible application of some styptic solution, and the expenditure of not a little time. "In all cases," writes MacCormac, "its prolonged use materially increases the subsequent bleeding from the smaller vessels in the stump, and often necessitates the application of double or triple the number of ligatures commonly employed."

It is needless to point out that these circumstances militate against primary healing.

After the sutures have been applied, and the stump dressed, more oozing continues very often than is to be expected when no constricting band has been employed.

In any case the band would appear to increase the amount of venous hæmorrhage.

In the second place, Esmarch's tourniquet, if long applied, has apparently the effect of hindering the healing process, and this is not improbably due to some very superficial sloughing, or to an undue reaction following upon the release of the vessels from pressure.

In the third place, the band, if applied near to the site of the amputation, may interfere with the retraction of the divided muscles, may embarrass the operator, and may even slip off during an important stage of the operation.

In the fourth place, some temporary paralysis may follow, especially in the arm and in thin subjects, owing to long compression of the nerves of the limb; and I have been induced to believe that an unusual degree of pain may attend the earlier period of the patient's recovery.

It may be added, finally, that the use of Esmarch's tourniquet may render the surgeon a little careless, and may put in jeopardy the main vessels of a flap, which, if the tourniquet were not applied, would be approached with especial care.

In some cases, without doubt, this elastic tourniquet is very useful. It is simple and handy, is readily applied, and retains its position. Moreover, it controls all bleeding completely. It has been of especial service in amputations at the hip and shoulder joints, and its application is described in the sections dealing with these operations.

It is useful, also, in instances where the surgeon has to operate with little assistance, or, at least, without competent help, and in some cases of very muscular or very corpulent subjects.

I would venture to think, however, that its use should be limited to exceptional cases, and that it should not be regarded as a necessary appendage to all amputations.

The elastic bandage employed with Esmarch's tourniquet is of somewhat doubtful value.

It is true that it empties the limb of blood, and forces it back into the general circulation. The extremity is rendered anæmic, and the blood that would have been lost with the limb, if no bandage was used, is saved to the patient.

I am not aware that this economy in blood has been proved to be of substantial worth. Parts which have been long rendered anæmic are not placed in the best condition for ensuring primary healing; and, moreover, if the forcing of a quantity of blood into the general circulation increases the blood pressure at the time, the possibility of an abnormal amount of oozing has to be anticipated. If a patient cannot afford to lose the amount of blood which will be lost in an

amputated limb, it may be a question as to how far the amputation itself is justifiable.

The bandage may have the effect of displacing clots. It should certainly not be applied to a limb the seat of suppuration or gangrene; and in the case of malignant growth, the "emptying" of the extremity by means of elastic pressure, and the actual compression of the growth itself, may be attended by no little risk.

I have long since entirely abandoned the use of the bandage; and it appears to me that the end aimed at—so far as the saving of blood is concerned — may be more efficiently and more safely attained by keeping the limb elevated for some little time before the main vessels are compressed and the knife introduced.

(c) *Digital compression of the main artery* is the best method of controlling bleeding during an amputation, and should be employed whenever possible.

It requires a skilled and strong-handed assistant. The pressure upon the artery can be well localised, well regulated, and rendered precise.

The main vein need not be included in the compression, as in the case of the femoral vessels at the groin. The brachial artery, however, could scarcely be occluded without at the same time obliterating the lumina of the companion veins.

The pressure need not be applied for a moment longer than is required, and can be at once relaxed, and at all times accurately controlled. It is limited to the part required; there is no general compression of the soft tissues, and no injurious compression of nerves.

The fingers of a skilled assistant are more reliable than any tourniquet, and are less likely to shift their position.

They have that intelligent hold of the artery which the most ingenious tourniquet must of course lack.

Special means of controlling hæmorrhage may be required during disarticulations at the hip and shoulder. These measures are considered in the sections dealing with those operations.

Putting aside these particular circumstances, it may be said, in general terms, that digital compression should be employed during all amputations.

If the artery be well controlled, the method has the principal claim to be termed "bloodless," especially when the operation is of some duration.

It should be remembered that the question of controlling bleeding during amputation has been much modified during recent years.

In the first place, the introduction of pressure forceps, which can close any vessel in a moment, has very greatly simplified the means for arresting hæmorrhage.

In the next place, amputation methods have altered. Limbs are not slashed off, and main vessels sliced open, as was a common practice some fifty years ago.

Many flaps are now so carefully and methodically cut that each vessel as it is divided is secured by pressure forceps.

In any case, the main vessels are clamped as soon as they are severed. In some amputations it is possible for these trunks to be secured before they are divided.

The assistant who controls the artery must have anatomical knowledge and strong hands.

In the upper limb, in children, in aged and emaciated subjects, the compression can be easily kept up.

In the lower limb, in the corpulent, and, above all, in the very muscular, the pressure is not so readily maintained.

In such cases, and in instances where the amputation involves much time, two assistants are required, or aid may be given by means of a screw tourniquet or weight, which can be adjusted upon the assistant's fingers.

In all amputations below the hip and the shoulder the compression is concerned only with the femoral artery against the os pubis, and the brachial artery against the humerus.

CHAPTER IV.

THE INSTRUMENTS REQUIRED IN AMPUTATION.

THE actual instruments needed in each amputation are enumerated in their respective sections.

The Amputating Knife must necessarily vary according to the character of the operation. The great alterations made in recent years in the mode of performing amputations have had an equally pronounced effect upon the chief instrument. The enormous knives employed some thirty or forty years ago have ceased to be used. Such a knife is depicted in Fig. 97, from Fergusson's "Practical Surgery." The author, in his description of the figure, remarks: "The knife, in my opinion, the artist has represented a little too long;" but in the same work knives of a proportionate length are depicted without comment. For an amputation at the hip-joint in Fergusson's time a knife with a cutting edge of from twelve to fourteen inches was employed. At the present day that operation is commonly effected with a knife no larger than the instrument used for excising a breast.

A good amputating-knife should possess the following characters:—The handle should be large and strong and from four and a half to five inches in length. Its sides should be flat and its edges cut square. Its surfaces should be well roughened.

With regard to the length of the blade, it must be remembered that, when force and precision are required, the blade must be short and the handle large and strong. This is well illustrated by Syme's amputation, for which operation no instrument is better suited than an old resection-knife, the blade of which has been shortened and narrowed by repeated "settings."

For transfixion operations the length of the blade should

be equal to that of one diameter and a half of the limb, and the same rule applies roughly to the knife required for the circular operation.

Over these long blades the operator has little control, as will be shown if he attempt to complete a transfixion or circular amputation with the long knife used at the commencement of the operation.

In performing an amputation at the hip by antero-posterior flaps cut by transfixion, the point of the knife has been thrust into the femur and broken against that bone, and has found its way into the thyroid foramen, into the scrotum, and into the thigh of the opposite side.

In a good amputating-knife the blade is light and narrow, and the back not too heavy. The point of the knife is nearly lancet-shaped, and the very tip corresponds to the extremity of a line drawn along the long axis of the knife and through the centre of the blade (Fig. 72). It is convenient in transfixion amputations that the extremity of the steel should be double-edged (in Fig. 72

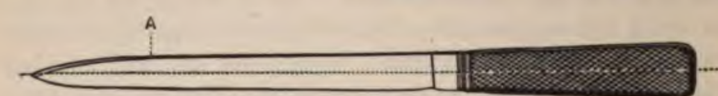

Fig. 72.—TRANSFIXION AMPUTATION KNIFE.

The double edge extends from the point to A. The dotted line indicates the centre of the blade.

as far as A). There is no prominent "heel" to the knife to engage the tissues and embarrass the surgeon's fingers. The point is not too fragile.

In the smaller knives—such as are adapted for cutting flaps from without inwards—the point may be a little nearer to the dorsum than to the cutting edge, and the edge itself may be a little rounded (Fig. 74).

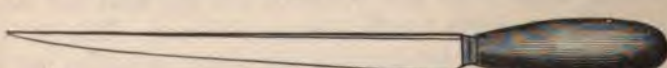

Fig. 73.—AMPUTATION KNIFE WITH EVERY BAD QUALITY.

Fig. 73 shows an amputating-knife with almost every bad quality—a long knife with a small, weak, smooth handle; a

blade with a heavy back, a projecting heel, and a tapering and fragile point.

The instrument styled in instrument-makers' catalogues "a metacarpal knife," may be taken to represent the worst form of knife that could (within reasonable limits) be used for amputating a finger at a metacarpal joint or for removing a metacarpal bone.

The immense broad-bladed knives figured by some authors as adapted for amputation by the circular method belong to a past age.

The catlin, or double-edged knife, has now fallen into disuse. No such instrument is required to divide the soft parts between the tibia and fibula. The knife is not only quite unnecessary in any amputation of the leg, but in the hands of the inexperienced is dangerous.

A useful instrument in all amputations is a good stout scalpel with a substantial handle.

The Amputating-saw should be broad and long in the blade and have fine teeth. The blade is about ten inches in length, and two and a half inches in width. Those with movable backs are the most convenient, and enable the sawing edge to be reduced to the narrowest possible dimensions.

The bow saw, or Butcher's saw, is best adapted for amputations in which a curved or oblique division of a bone is desired.

Fig. 74.—AMPUTATION KNIFE USED FOR CUTTING FLAPS FROM WITHOUT INWARDS.

Many **retractors** have been devised for the purpose of protecting the soft parts during the application of the saw. The simple linen two-tailed retractor answers well enough. The fingers of one or more intelligent assistants answer better. A three-tailed linen retractor may be used in amputations through the leg and the forearm. Three ivory spatulæ placed close to the bone, and made to cross one another in the form of a triangle, represent an admirable retractor.

The other instruments used call for no especial comment.

The following is **the list of instruments** which may be required in the performing of an amputation:—

- Tourniquet.
- Amputating Knives.
- Stout Resection Knives.
- Scalpels.
- Saws.
- Lion Forceps.
- Bone Forceps.
- Periosteal Elevators.
- Linen Retractors.
- Ivory Spatulæ.
- Volkmann's Spoon.
- Gouge.
- Dissecting and Artery Forceps.
- Pressure Forceps.
- Tenaculum.
- Scissors, Probe, Straight Needles, Ligatures, Sutures, Dressings.
- Irrigator.
- Kidney-shaped Receiver.
- Splint or Support for the Stump.

CHAPTER V.

METHODS OF PERFORMING AMPUTATION.

THE following are the principal procedures in amputation:—

1. The Circular Method.
2. The Modified Circular Method.
3. The Elliptical Method.
4. The Oval *or* Racket Amputation.
5. The Amputation by Flaps.

1. The Circular Method.—In this method of amputation the soft parts are divided by a series of circular cuts, made from the skin down to the bone. The tissues are not divided by one sweep from integument to periosteum, but by successive cuts, in such a way that the skin and the layers of muscle are severed at different levels. The history of this operation has already been alluded to (page 262).

Two forms of circular amputation are practised at the present day. They are identical in principle, and their differences, such as they are, depend upon anatomical features, and are indeed influenced only by locality.

A. The ordinary circular amputation—the *amputation circulaire infundibuliforme* of the French—is illustrated by an amputation through the arm or thigh. In these parts the bone is more or less evenly surrounded by thick muscles. After each circular cut the soft tissues are allowed to retract, or are retracted, before a second sweep is made with the knife. The result is that the wound becomes funnel-shaped; the edge of the funnel is formed by the divided skin; the apex of the funnel, or infundibulum, by the divided bone.

In performing a circular amputation the surgeon stands to the right-hand side of the limb to be removed, *i.e.*, to the outer side of the right upper or right lower limb, and to the inner side of the left limbs. The operator is thus able to grasp the limb above the site of the amputation with his left hand. In

removing the left arm it may be more convenient to stand to the outer side of the extremity.

The precise position of the circular incision below the level of the future saw-cut must vary with the site of the amputation and the condition of the limb. It is indicated in the descriptions of the particular amputations.

The general method of performing the operation may be illustrated by an amputation of the thigh.

The surgeon grasps the limb above the site of the incision with the left hand and retracts the skin.

In this retraction he should be aided throughout the operation by an assistant, who draws up the soft parts both before and after division with both hands, one applied to either side of the limb. In this way a much more even and complete retraction is obtained than is possible if the surgeon relies upon his left hand alone.

Grasping the knife in the full hand—as he would hold a pruning-knife—the operator passes his arm beneath the limb and brings the knife over its upper surface. The incision is commenced with the heel of the blade, while the point is directed towards the operator's feet. The cut should begin well upon the outer side of the thigh. To facilitate this an assistant should rotate the limb inwards to its utmost.

In drawing the knife round the limb the surgeon cuts from the heel of the knife to the point. As the blade passes round the thigh the assistant who holds the leg rotates the extremity outwards, so as to make the skin (as it were) meet the surgeon's knife.

The incision can be made to traverse two-thirds or more of the circumference of the thigh in one sweep and without the hold upon the knife being altered. The remaining part of the circular wound is completed by a separate cut made in the opposite direction, *i.e.*, by cutting from the commencement of the first incision to the point where it ended. While effecting this the limb is once more fully rotated inwards.

Some surgeons appear to consider it important that the circular cut should be made in one sweep of the knife. To effect this the surgeon has to crouch down, or even—according to the advice of some—to rest upon one knee when commencing the incision During the passage of the knife around the

thigh, the operator has to alter his grasp of the handl
single circular sweep may be admirable as a demonstr
sleight of hand, and may be considered to justify tl
what ridiculous attitudes assumed by the performe
surgical procedure it is not to be commended. The
so effected is usually imperfectly made, and is almost ir
of unequal depth, for in the terminal part of the c
surgeon has a diminished control over the blade.

From repeated experiments, I think I may say
circular division of muscles, in a large limb, made
sweep of the knife is invariably defective and unequa

In dividing the integuments, the blade should
throughout absolutely perpendicular to the surface, an
extend no deeper than the deep fascia.

The next step in the operation consists in fre
integuments so that they can be further retracted.

While the assistant, directed and aided by the s
left hand, draws up the divided skin fully and eve
knife is passed round the limb close to the edge of t
so as to divide all bands connecting the integument
deeper tissues. Especial and distinct bands are usual
in the lines of the main inter-muscular septa.

In effecting this freeing of the skin, the kn
throughout be kept perpendicular to the surface.
desirable to pass the blade obliquely beneath the int
for the purpose of dividing its connections. Such a p
not hasten the retraction, nor make it more comp
tends to render it uneven, and to damage the futu
covering of the stump. In the ordinary circular am
the skin is not *dissected* up.

When the retraction of the skin is complete, the
should be laid bare and be covered only by t
fascia.

The knife is now passed through the superficial
precisely in the same way as it was made to trav
skin. The blade is kept close to the divided inte
and still quite perpendicular to the surface. The s
are fully and evenly retracted, and the limb is rotated
the knife in the manner already described.

The divided tissues are again well and regularly r

and the knife by a third circular sweep passes through the deeper muscles and reaches the bone.

A fourth incision may be needed to fully clear the bone of muscle tissue, and this can best be effected by a stout scalpel.

Throughout the operation care must be taken that the

Fig. 75.—CIRCULAR AMPUTATION *à la manchette.*

retraction is even—or is modified as required—and that the knife is held always with a perpendicular blade.

The formation of a periosteal flap is considered below (page 305).

The severed muscles now form a cone, the apex of which is at the bone bared for the saw.

The retractor is applied and the bone sawn through.

In the description which follows, illustrations of the ordinary circular amputation are afforded by an amputation of the arm (page 375), and an amputation of the thigh (page 514).

B. The circular amputation *à la manchette* is adapted for parts where the covering of the bones is scanty and is composed of irregular tissues. Such a region is best illustrated by the wrist, where the bones are surrounded by many tendons, and where muscular tissue is scanty and unevenly disposed.

In this method of amputating, the skin and subcutaneous tissues are dissected up in the form of a cuff, or *manchette*, and are turned back like the cuff of a coat.

The skin is divided, as in the previous operation, by a circular incision, and is then, together with the subcutaneous tissues, turned back as shown in Fig. 75. The turning back of this cuff is mainly effected by the fingers of the surgeon's left hand. The skin is freed by the knife, which should always be held perpendicular to the surface. The cuff is not *dissected* up. It is gently freed and turned up. If the knife be passed obliquely beneath the skin which has to be everted, it is apt to be needlessly damaged.

The cuff must be even and regular, and of a size previously determined upon.

The soft parts are then divided by a circular sweep, with the knife at the level of the retracted and everted skin.

But one such incision will probably be necessary.

It is only about the wrist or the lower part of the fore-arm that a real cuff of skin can be formed.

In the arm or the thigh of thin and wasted subjects the formation of a "cuff" is possible, but should not be practised, inasmuch as it involves a needless disturbance and damaging of the integuments which will cover the future stump.

In the lower part of the leg, in the region of the ankle, a *manchette* may be formed in thin subjects, but it is not easy to effect, and should not be carried out, for the reasons already mentioned. The difficulty of retracting the skin in this region is usually met by making one or more vertical incisions in the integument in addition to the regular circular incision.

The present variety of the circular amputation is therefore practically limited to amputations through the wrist or lower part of the fore-arm, and is illustrated, in the account which follows, by the latter operation (page 358).

The two forms of circular amputation may be to some

extent combined, a cuff of skin being turned up upon one aspect of the limb and the integuments simply retracted upon the other. This is illustrated by the circular amputation of the leg at the place of election (page 485).

In order to allow for unequal retraction of the skin in some parts, the circular incision may have to be obliquely placed. It ceases, however, to be oblique when the integuments have been allowed to retract. An illustration of this is afforded by the circular amputation at the elbow-joint (page 366).

2. **The Modified Circular Method.**—Three important modifications need to be described: (*a*) In addition to the circular cut through the integuments, a vertical incision is made to join the original wound. The skin on either side of this vertical cut, and at the points where the cut joins the circle, is then reflected in the form of two imperfect skin flaps.

This modification is illustrated by one form of supra-malleolar amputation (page 466).

(*b*) Two vertical incisions are made to join the circular wound. By this use of the knife, two square skin flaps can be dissected up, and the muscles, when exposed, can be divided by a circular sweep of the knife.

This plan is also described among the supra-malleolar amputations.

(*c*) The modification suggested by Liston, and extensively practised by Syme—with whose name the method is associated—is strongly recommended by many surgeons of the present day. Two very short flaps, of semi-lunar outline, and of equal width and length, are dissected up. They are composed simply of the skin and the subcutaneous tissues, and consist of little more than curved incisions made across opposite surfaces of the limb, each being equal to one-half of the circumference of the limb.

The skin beyond the bases of the little flaps is then retracted as a whole, just as in the usual circular amputation. When the retraction has been carried to a sufficient extent, the muscles are divided by circular incisions in the usual way. This method is illustrated by an amputation of the thigh (page 515).

3. **The Elliptical Method.**—This operation was adopted by Sharpe, of Guy's Hospital, as an improvement on the circular

method, in the middle of the last century. French surgeons attribute the operation to Soupart, of Liège (1847), and style it *la méthode de Soupart.* It is sometimes described as a variety of the oval method. It occupies an intermediate position between the circular operation and the amputation by a single flap.

The incision in the skin is elliptical or lozenge-shaped (*le mode losangique*). The position and inclination of the ellipse vary according to the site of the amputation, and have to be carefully estimated (*see* Disarticulations at the Elbow-joint). The skin and subcutaneous tissues are then retracted, by gliding, as in one amputation at the wrist (page 348), or by the turning up of a cuff, as in the disarticulation at the elbow by a posterior ellipse (page 368), or by the separation of a definite flap, as in Guyon's supra-malleolar amputation (page 464).

The muscles are usually divided as in the circular operation. They may be, however, cut in part by transfixion, as in the disarticulation at the elbow-joint by an anterior ellipse.

The elliptical method is well adapted for amputations through certain joints, and is illustrated in the following sections by the operations just alluded to.

4. **The Oval** or **Racket Method.**—The oval operation, or the method of Scoutetten, was definitely formulated by that surgeon in 1827. The skin incision takes the form of an oval with one end pointed, or of an isosceles triangle rounded at its base. The edges of the resulting wound are united in its long axis. The soft parts beneath the skin are divided down to the bone by cutting from without inwards. This operation is illustrated on a small scale by some amputations at the joints of the fingers and toes, and on a larger scale by Guthrie's amputation of the arm just below the tuberosities of the humérus (page 381).

A modification of the oval method is accredited to Malgaigne (1837). To obtain a better exposure of a joint without loss of substance, and to afford a better covering for the bone in the upper part of the wound, Malgaigne extended a longitudinal cut from the apex of the oval, producing thus *l'incision en raquette,* the longitudinal wound forming the handle of the "racket." This incision is also called by the

French *l'incision en croupière,* and in some amputations it certainly more closely conforms to the outline of a "crupper" than to that of a "racket."

In this category is placed also the T-shaped incision—an incision formed of a circular cut joined by a longitudinal one. The racket, crupper, and T-shaped incisions are best illustrated by disarticulations at the metacarpo-phalangeal and metatarso-phalangeal lines of joints (Figs. 82 and 100).

Amputation by the racket incision is also illustrated by certain disarticulations at the shoulder and at the hip joints.

5. **The Flap Method.**—The methods of performing amputation by means of flaps are numerous and varied, and have been subjected from time to time to so many modifications and re-modifications that a systematic classification of flap methods is scarcely possible.

A. *Skin Flaps and Muscle Flaps.*—Any flap or flaps may be composed of the integuments only, or of the integuments and the subjacent muscular tissue. Some difference of opinion has existed as to the merits of skin flaps and muscle flaps.

In every flap the skin must be cut longer than the muscle tissue. A flap containing too much muscular tissue is unwieldy; it is difficult to adjust, and the muscle is certain to protrude. In endeavouring to bring the edges of the skin together, undue strain is apt to be placed upon the sutures. Much of the muscle tissue, being far removed from its blood supply, may slough. If, however, the part heals well, the resulting stump is firm and well-rounded, and the end of the bone is well covered.

A flap composed of skin only is very apt to slough. This tendency is least observed in the integuments about joints, where the vascular supply of the skin is derived from many channels; elsewhere an extensive skin-flap is very liable to perish for lack of blood. The skin-flap is easily adjusted and falls readily into place. It affords, on the other hand, but a slight covering to the bone, and a scanty protection to the stump. The skin, however, in some regions is accustomed to withstand pressure, and affords an excellent covering for the stump. Such regions are illustrated by the heel, the front of the knee, and the back of the elbow.

It is urged that the skin covering a stump does not waste to an appreciable extent, but that the muscular tissue contained therein undergoes complete atrophy in the course of time, so that the stump fashioned out of muscle-flaps is reduced at some period to the condition of a stump with a covering composed of integument only.

While it is true that the actual muscle fibres in the stump become more or less completely atrophied, there remains behind a solid pad of fibrous tissue in which the sheaths and fibrous connections of the divided muscles form the most important elements, and in which the bone is buried.

In general terms therefore it may be said that the best flaps are those which contain muscular tissue, provided always that the skin covering the stumps be longer than the divided muscles which it contains. The amount of muscle contained in the flap must depend upon the situation of the amputation, the contractility of the divided muscles, and the covering required for the bone. If it be considered desirable that a flap should contain a main artery, this cannot be effected unless a muscular flap be dissected up.

B. *Varieties of Flaps.*—1. Single Flap.—This was the original *method of Lowdham.* A single flap involves a considerable sacrifice of tissues upon one aspect of the limb. It is well adapted, however, for certain instances of amputation for limited injury or disease.

As an example of amputation by single flap formed of skin only may be cited the disarticulation at the knee-joint by a long anterior flap (page 497), and as examples of single muscular flaps Farabeuf's amputation of the leg at the place of election (page 479), the disarticulation at the wrist by a single external flap (page 352), and the amputation at the shoulder-joint by a deltoid flap (page 391) may be quoted.

2. Double Flaps.—Ravaton (1739) made a circular incision down to the bone, and then added a longitudinal cut on either side of the limb, so as to form two square flaps, each equal to half the thickness of the limb. These so-called flaps consisted of unwieldy square blocks of muscle, and the resulting stump was uncouth. "*Ravaton's method,*" although the prototype of the operation by double flaps, cut from without inwards, soon ceased to be practised.

Vermale's method laid the foundation of the double-flap operation of modern times. Vermale cut both flaps—whenever possible—by transfixion, and was thus enabled to fashion them more neatly and to reduce the amount of muscular tissue left in the stump.

Sédillot's method differed from Vermale's in that the operator, instead of keeping his knife close to the bone in transfixing, passed the knife through the muscles nearer to the surface of the limb. Each flap so fashioned contained but a small portion of muscular tissue. The remaining muscles, together with the great vessels, were then divided by a circular incision and the amputation completed as in the ordinary circular operation.

This procedure is nearly identical with the modified circular method.

Langenbeck's method consists in cutting double flaps from without inwards, thus elaborating Ravaton's operation. This plan enables the surgeon to fashion the flaps with great precision, and it is the method of flap-cutting most usually adopted at the present day.

A combination of the two last-named methods soon became common in amputation through the leg. The anterior flap was cut from without inwards and the posterior by transfixion.

Some surgeons (Dupuytren, Larrey) made the skin incisions by cutting from without inwards, and then completed the flaps by transfixion. (*See*, as an example, amputation of the arm by antero-posterior flaps.)

Among the more specialised methods of cutting flaps may be named *Teale's method*, fully described in the account of amputation of the leg; and *Lister's method*, which is detailed in the description of amputation through the condyles of the femur.

Double flaps may be lateral or antero-posterior. They may be equal in size or unequal. In order to meet the cylindrical form of the limb, the flaps will be better fitting if made of U shape than if cut square. Double flaps are generally so made as to be equal in width.

Examples of every form of double flap occur in the description of individual operations which follows.

C. *Modes of Cutting Flaps.*—The methods of fashioning flaps have been already in general terms alluded to. Considered more in detail, and from the point of view of the manipulation of the knife, three methods of cutting flaps may be specified :—

1. By transfixion.
2. By cutting from without inwards (*par entaille*).
3. By dissection (*par désossement*).

In cutting by transfixion a long knife, equal in length to one diameter and a half of the limb, is employed. The following is the description of an amputation of the arm by double flaps cut by transfixion as given in Heath's "Operative Surgery":—"The limb being held away from the trunk by an assistant, the operator grasps the biceps, with the brachial vessels and nerves, and entering the point of the knife upwards close below his thumb, passes it in front of the humerus, depressing the point as it appears on the opposite side close to the operator's fingers. With a steady sawing movement, a flap from two to three inches long is cut, with the skin left longer than the muscles. Drawing up the flap with his fingers, the operator passes the knife behind the bone, and cuts a slightly larger flap behind, bringing out the knife abruptly at the last. Both flaps being gently retracted, the knife is swept round the bone, which is then sawn steadily through, the thumb and fingers of the left hand protecting the soft tissues."

By another method the skin incisions may be made by cutting from without inwards and the exposed muscles be then divided by transfixion. This is illustrated by the amputation of the arm by antero-posterior flaps (page 376).

2. In cutting a flap from without inwards, the outline of the future flap is at first marked out by an incision which concerns only the skin and the subcutaneous tissues. When the skin has retracted, the muscles are divided down to the bone by cutting from without inwards.

For this purpose a small but strong knife is employed (Fig. 74), and the edge is directed obliquely towards the bone, so that the muscular tissue shall be cut unevenly, the thinnest section being along the margin of the flap, the thickest at its base.

An illustration of this method is afforded by the disarticulation at the shoulder-joint by an external or deltoid flap (page 391).

As the skin is allowed to retract before any muscular tissue is cut, the integument of the stump must of necessity be longer than the contained muscle.

3. In separating a flap by dissection, the flap is at first marked out by a skin incision, and when the integuments have sufficiently and evenly retracted the muscular part of the flap is cut with great care. The knife is passed obliquely through the muscle to the bone, and the soft parts forming the apex of the flap having been completely divided, the rest of the deeper tissues of the flap are very carefully dissected up or peeled off from the bone.

This method is well illustrated by the amputation of the leg at the place of election by a single external flap.

Here the flap, from its base to its apex, contains the anterior tibial artery, and the mass of muscular tissue forming the flap is peeled from the tibia, fibula, and interosseous membrane.

CHAPTER VI.

The Selection of Methods for Amputating.

In selecting a specific method for performing an amputation respect must be had for the adage that "the coat must be cut according to the cloth." Each case must be taken upon its merits, and regard be observed for the structural condition of the limb.

A method well adapted for a stout or muscular subject in the prime of life may not be suited for an identical operation when performed upon a much-wasted, aged, or cachectic individual. In performing a circular amputation, retraction of the skin may be rendered difficult by reason of existing œdema or induration; or the integuments may have been rendered rigid and adherent by a long-abiding inflammation.

The muscles also may not contract when divided; they may be found atrophied, or converted into fatty or fibrous tissue, or be matted together by inflammation, or be paralysed from disease or disuse.

Flaps likewise may have to be modified to avoid diseased districts, ulcers, sinuses, and the like. The skin and muscles may not contract on division. The muscular tissue may be so atrophied that enough scarcely remains to form the substance of a substantial flap.

The main artery of the limb, or the vessel which is to form the principal artery of the flap, may be found to be occluded and the circulation to be diverted into many collateral channels. In such case the main vessels may scarcely require a ligature, while hæmorrhage will occur from a number of divided arteries anatomically insignificant.

It is recommended in some amputations—notably the amputation of the leg by a large posterior flap—that the main nerve (in the case cited, the posterior tibial) should be removed by dissection. On performing the operation the

nerve may be found to be buried among a mass of inflammatory material, and its excision to be so difficult as to render the necessary prolongation of the operation unjustifiable.

In the comments upon the various methods of amputating described, the comparative value of each procedure is discussed.

It is difficult to claim an unreserved superiority for any one method. While in one situation the circular amputation is undoubtedly the best, in another it is with equal certainty the least efficient method of dealing with the part. The same may be said of any one method of performing amputation by the cutting of flaps.

The main points to be considered in *the selection of a method* are the following:—

1. The least sacrifice of the healthy tissues of the limb.
2. The providing of a good and permanent covering for the bone.
3. The obtaining of as small a wound area as is consistent with the proper performance of the amputation.
4. The securing of a good blood supply for the flaps or tissues which will form the stump.
5. The production of a well-adjusted cicatrix, and one so placed as to assist the healing process, secure efficient drainage, and be removed from pressure when the stump has healed.
6. The ease with which the bone can be exposed at the saw-line, and the general simplicity of the method.
7. The cutting of the main vessels transversely.
8. The rapidity with which the amputation can be performed.

The last point, which was at one time almost the most important, is now one of the least to be considered. Before the days of anæsthetics, speed was the primary good quality in any amputation method, and it was customary to estimate the value of a procedure, first of all, by the number of seconds or minutes involved in the removal of the limb.

Chloroform and ether have entirely changed this ground for criticism—wider issues are now concerned; the minimum sacrifice of parts, and the well-being and utility of the stump, are now primary considerations, and amputations are effected

with some of the care and precision which characterise the plastic operations of surgery.

The *elliptical* and *oval* methods require no further consideration. They are founded upon the circular operation, are of limited application, and are admirably adapted to the parts at which they are practised.

In comparing the circular and flap methods one conspicuous consideration is the resulting wound area.

The investigations of Farabeuf show that in a limb with a diameter of 10 c.m. the wound area (*la surface saignante*) of the stump will be 110 square c.m. after both the ordinary circular amputation and the amputation by two equal rounded flaps, and will be 125 square c.m. after an amputation by a single rounded flap.

The *circular operation* provides, then, a small wound surface. It involves the least sacrifice of the healthy limb; it is easily performed; the blood-vessels and muscles are cut cleanly and transversely, and the soft parts covering the bone are well supplied with blood.

On the other hand, the operation cannot be well performed without an assistant; the exposure of the bone at the saw-line is not always effected with ease and without undue disturbance of the soft parts, and the edges of the wound do not fall easily together. Moreover, in muscular limbs the after-retraction of the divided muscles is very apt to lead to a conical stump. Indeed, one of the most common examples of such a stump is provided by carelessly performed circular amputations of the thigh in muscular subjects.

In wasted individuals, and under conditions where muscular retraction is inconsiderable, this objection does not hold.

The circular method is not adapted for cases of injury or disease when the parts near the site of the amputation are unequally involved.

The *flap method*, as represented by flaps cut either from without inwards or by dissection (*see* page 297), is capable of adapting itself to many conditions and to any part.

It is particularly valuable in instances of unequal destruction of the parts of a limb.

The area of the wound surface may be as already pointed

out, larger, and, other things being equal, it may be allowed that the flap operation involves a greater sacrifice of tissue than does the circular. The blood-vessels may be cut obliquely, and may even be slit up. The muscles are divided obliquely. In long flaps there is a danger of their tissues perishing from an insufficient blood supply. The operation is in some forms difficult, but can usually be performed with less skilled assistance.

On the other hand, the bone at the saw-line can be readily exposed; the flaps fall easily together; the site of the future scar can be modified as required; the coverings of the stump can be fashioned so as to meet the varying conditions of the limb, and the development of a conical stump can be more surely avoided after a flap amputation than after the circular operation.

As to the cutting of the flaps themselves, the methods by cutting from without in and by dissection are, beyond doubt, the best. Flaps so fashioned can be formed with great precision. The proportion of contained tissue can be determined with accuracy, and the exact relations between the amount of skin and of muscle covering the bone can be regulated with ease. Main vessels need never be slit up, and, indeed, under many conditions these structures may be exposed and secured before division. By these methods also the smallest possible section of muscles can be accomplished.

Some part of a flap may be conveniently cut by transfixion, as in Hey's amputation through the middle of the leg, and the disarticulation at the elbow-joint by the elliptical method. The part so divided must belong to the muscular portion of the flap.

The cutting of a large flap by transfixion alone, in such a way that the knife divides both muscles and integument at one sweep, is to be strongly condemned.

The method has one recommendation only—it is rapid.

If the rapidity with which a limb can be removed should prove in any case to be a matter of the first importance, then the amputation by flaps cut by transfixion may be entertained. Such operations are described in connection with amputations of the thigh, and disarticulations at the hip-joint.

issue. The muscles themselves are cut obliquely. vessels may be transfixed, or may be cut unduly may be sliced up. Much tissue at the bases of escapes division, and requires to be cut before the be cleared for sawing.

ethod belongs to the past, to a period of "brilliant" hen the shrieking and terror-stricken patient was the amputation-chair by many lusty assistants, perator's pupil stood by with a fob-watch in his

CHAPTER VII.

General Points in the Performance of Amputations.

A. **The Handling of the Knife.**—It is needless to point out that an amputating-knife is a powerful instrument, with the edge of a razor, and that it must be wielded with infinite care and precision. It is a dangerous instrument in the hands of the surgeon who believes that limbs should be "slashed off," and that an operator's ability is to be estimated by the number of seconds involved in the procedure. Flaps should be planned with the minutest care, and it is better that the lines of the intended incisions should be marked upon the limb in crayon before the operation than that the surgeon should trust to his eye and the hope that "the flaps will come together." Each incision should be made deliberately, and should be final.

The "trimming" of flaps is usually an evidence of incompetence.

The greatest possible care should be taken of the principal arteries, lest the stump be left anæmic.

In the hasty and careless cutting of flaps, especially by transfixion, it is very easy for the main artery of the part to be slit up or divided at too high a level.

Nerves and tendons should be cut short, arteries long.

In dividing tendons a sharp, vigorous cut is needed, and the tendon should be put upon the stretch at the time the knife is applied.

If after the limb be removed any tendons are left "long," *i.e.*, hanging from the surface of the stump (as may occur after Syme's amputation), they should be seized with bull-dog artery-forceps, put on the stretch, and divided by strong scissors. Loose tendons are not readily severed by a knife.

B. **The Handling of the Saw.**—Care should be taken, in

the first place, that the bone is not bared too high above the site of the future saw-line.

If a *periosteal flap* is to be made, this membrane itself should not be actually exposed. A flap large enough to cover the divided end of a bone, and composed solely of periosteum, is probably useless and destined to slough.

The flap should contain not only the periosteum, but the deepest muscular layers about the bone. These two tissues should be separated from the bone together. It is through the muscular tissues that the blood-vessels reach the periosteum.

A circular incision having been made down to the bone, at a proper distance below the intended saw-line, two vertical incisions—one on either side of the bone—are then made from the site of the saw-line, to join the circular cut. Two equal flaps of musculo-periosteal tissue are then dissected up with a periosteal elevator, are carefully protected while the bone is being sawn, and are allowed to fall over the divided end of the bone when the flaps are adjusted If thought desirable, one or two points of suture may be introduced to secure the little flaps in place. In young subjects the periosteum separates readily, and the same may be said in some instances of operation for disease. In these cases the vertical incisions may be dispensed with, as they may also be when the amputation concerns small bones. In dealing with the tibia and femur, however, forcible attempts to separate a periosteal sheath without the aid afforded by lateral incisions not improbably inflict a permanent damage upon the little flap. In healthy adults the membrane is often difficult to detach.

The value of the periosteal flap has not yet been clearly demonstrated in all cases, and it may be a question whether it is always worth the time involved in its production. Its most elaborate and apparently most beneficial application has been associated with amputations at the hip-joint.

In using the saw, the first care is to make a groove on the bone in which the saw shall run smoothly, without risk of slipping and damaging the soft parts around.

It is well to fix the thumb-nail of the left hand into the bone just above the saw-line, while the blade of the saw is rested and steadied against the knuckle of the thumb.

The saw should be held quite lightly at first, and should be drawn from heel to point in making the groove.

The bone can then be divided by long, firm, slow cuts.

The whole length of the saw-blade should be used. The hand should be light.

Rapid sawing is bad, as is also the use of large and coarse-toothed saws. A not inconsiderable amount of heat is developed during the sawing process, and it is possible that the superficial necrosis of the entire sawn end of the bone, sometimes met with after amputation, may be due to the rough and violent use of the saw.

As the division of the bone approaches completion the strokes made with the saw should be short and again very light.

When two bones require division, a good groove should first be made in the larger one, and when the saw has obtained a sure hold its edge can be dropped upon the smaller bone.

The division of the smaller or more movable bone should be completed first.

During the sawing process, MacCormac advises that a stream of carbolised water should be allowed to pour over the bone.

Special methods for dividing the tibia and fibula are described in the account of Farabeuf's amputation of the leg at the "place of election."

Every care should be taken that the soft parts are well protected during the process of sawing.

The assistant who holds the limb should hold it horizontally and at right angles to the saw-blade. If the limb be held too high or too low, or be not properly supported close below the site of the amputation, the saw is apt to be locked, or the bone to break before its division is completed.

The assistant should draw the limb away from the trunk while at the same time he supports it efficiently.

Any splinters of bone should be removed with bone-forceps.

The division of small bones, such as those of the fingers or metacarpus, by bone-forceps is to be condemned. By such division the bone is crushed and splintered, and needlessly damaged. This is especially the case with the bones of well-developed adults and of aged persons.

The division of these slender, long bones is best effected by

means of a very fine saw, and for the purpose the smallest form of bow-saw answers admirably.

The not infrequent separation of spicules of necrosed bone after amputations of the fingers and toes is probably often due to the splintering and crushing of the bones produced by the bone-forceps. The forceps effect the division of the shaft speedily, but at a great sacrifice, and their use is opposed to one of the first principles of surgery.

c. **The Arrest of Bleeding.**—In arresting bleeding after amputations there is little to be noted in addition to what has been written in a previous chapter (page 57).

After the bone has been sawn, the stump should be supported by an assistant, who can, at the same time, hold up any flap and generally do his best to expose the whole surface of the wound.

The main vessels may have been secured before or during the fashioning of the flaps. In the majority of cases, however, this is not done. The surgeon and his assistants, the moment the wound surface is well exposed after the amputation, should seize all the visible divided arteries with pressure-forceps. The operator should secure the principal vessels, while one or more assistants grasp any minor trunks which may be noticed.

During this preliminary securing of the severed arteries, the pressure upon the main vessel should still be maintained by the assistant who is responsible for the control of hæmorrhage during the amputation.

While the ligatures are being applied the stump should be supported in an elevated position. In the case of the upper limb an assistant can readily effect this. After an amputation of the lower limb the stump should be supported upon a block similar to those used in dissecting-rooms to receive the head of the subject. The block is padded and covered neatly with macintosh, and, when in use, a towel soaked in some antiseptic solution may be placed over it. By this means the whole area of the wound is well exposed to view, the stump is kept perfectly steady, and is maintained at a convenient elevation.

Pressure upon the main artery being relaxed, any smaller bleeding points are secured with clamp-forceps.

The cut vessels are finally closed in the manner already described, some by pressure merely, some by torsion, the remainder by ligature (page 58).

It is well that a ligature should be placed upon the main vein, or upon any other vein from which blood continues to ooze.

Persistent bleeding from the sawn surface of the bone may usually be checked by gentle pressure maintained for some time with a piece of sponge. If it still continue, a piece of ice may be held against the oozing surface.

Bleeding from a distinct artery in the bone seldom calls for further means than these. Should it, however, be maintained, an attempt should be made to separate the coats of the vessel from the wall of the bony canal by means of a fine needle, and then to force them, when separated, into the canal so as to form a kind of natural plug.

Failing this, the orifice may be blocked by a piece of catgut, or by a small pellet of wax. I have never met with a case which called for the use of "the sharpened end of a wooden match" as a plug.

This plug, which so many authors allude to, is probably intended to be no more than a picturesque example of fertility of resource.

D. **The Closure of the Wound.**—The cleansing of the wound surface and the application of the sutures are conducted in the manner already described (page 58).

There should be no tension upon the wound, no dragging of the flaps together, no attempt to cover the bone by traction upon the soft parts. The edges should fall together.

To unite the wound a long, straight needle is employed and the best suture material is silkworm gut.

If the sutures are applied at a proper distance apart, and if firm and even pressure is employed, so as to approximate the wound surfaces and obliterate any cavities or pockets between the flaps, no drainage-tubes may be required. If a sinus has been exposed during the amputation, and has been scraped out, a tube may be allowed to occupy its cavity for a day or so if thought necessary. If the knife has passed through œdematous tissues, much oozing must of necessity occur after the operation, and to allow this to have free exit a tube may

be employed for 24 or 48 hours. The escape of the fluid, however, can usually be as well provided for by leaving suitable intervals between the sutures at the most dependent part of the wound.

The general question of the use of drainage-tubes has already been considered (page 64).

The stump must be properly supported after the operation, and care taken that all traction is, as far as possible, taken off the flaps. In a large proportion of the cases of amputation the support of a splint is required. The splint serves to support the flaps, to maintain the limb at rest, and to favour the application of such pressure as is required (Fig. 76).

Fig. 76.—SUPPORTING SPLINT ADJUSTED TO THE LEG AFTER CHOPART'S AMPUTATION.

More specific details as to the after-treatment of amputation wounds are given in the chapters which follow.

CHAPTER VIII.

THE FUTURE OF THE STUMP.

THE success of an amputation depends upon a great many factors. The more general of these have been already considered in dealing with the circumstances which influence the future of all operations (page 1).

The local conditions are also very numerous.

1. **The State of the Limb.**—In cases of injury, for example, the amputation may not be performed high enough up, the flaps may have been fashioned from damaged tissues, and the structures of the stump will perish in due course from sloughing or suppuration.

In removing a limb for any spreading disease, it is possible that the limits of the affected area have not been clearly recognised, and that the stump becomes in turn the seat of the malady for which the amputation was performed.

In operations for gangrene this is especially to be noted.

In senile gangrene, or in gangrene due to the plugging of a main artery, the involved segment of the limb may be removed. As the knife passes through the apparently healthy tissues it becomes evident that they also are on the verge of death. Little blood issues from the divided vessels. The vascular supply of the part has been sufficient to support a precarious existence, but it is insufficient to meet the demands made by that degree of inflammation which is necessary to effect healing. Under this strain the local powers of the part break down and the flaps themselves pass in turn into the gangrenous condition.

In amputations performed for sloughing conditions due to nerve lesions, the same sequel of events may be noted. The condition that led to the sloughing process is not removed by the surgeon's knife. Its influence affects the segment of the limb through which the blade has passed.

Tissues that could have lived if left undisturbed, cannot display the vital energy demanded in a healthy flap. The flaps, or portions of them, slough, or fail to heal, and the disease is said to have reappeared or recurred in the stump.

It should be remembered that, to secure the healing of an amputation wound, a robust recuperative power is required in the tissues concerned. This power is easily enfeebled. Thus a ready healing of the wound cannot be expected when the flaps are cut from tissues which have been repeatedly inflamed, or which are actually the seat of inflammation, or which have remained long œdematous.

Amputations for chronic joint-disease illustrate this well enough, especially if the flaps are cut from tissues within the actual area of the disease.

The tissues may, however, have become enfeebled from other causes than those attending inflammation. They may have wasted from long disuse. The muscles may be atrophied and fatty, the nerves converted in great part into connective tissue, and the arterial channels considerably reduced in size and capacity.

Although the subject in such case may be young, the tissues in the affected limb are in a condition of senile decay.

The long wearing of splints, the long use of tight bandages, the long maintaining of the limb in an elevated position, are all conditions which serve to place the parts in an unfavourable state for a successful amputation.

2. **The Site of the Amputation.**—It will be obvious that much depends upon the exact spot selected for an amputation and the state of the tissues from which the coverings of the stump are made.

There are few more difficult problems in practical surgery than the selection of the best site for an amputation, and few upon which less precise advice can be given.

If the operator make the securing of primary healing the main factor in deciding upon the amputation site, then he will over and over again sacrifice more of the patient's limb than was necessary or perhaps profitable.

If, on the other hand, he regard the minimum amount of tissue to be sacrificed by cutting as the first element in forming his decision, then he will meet with many cases where

the flaps slough and where the ultimate destruction of the limb is greater than would have occurred had the amputation been performed higher up in the first instance.

Few positions in surgery are more unsatisfactory than that involved by a second amputation rendered necessary by the sloughing of the stump of the first.

When the second stump has healed, the operator must feel that the patient might have been saved the former operation and the tedious, painful, and dangerous period which preceded the final amputation.

There is constantly the difficulty of deciding between the sacrifice of a few more inches of a limb to ensure ready healing and the saving of those inches at the risk of retarded healing, possible sloughing of the stump, and the subsequent removal of the limb at a spot above the higher of the two points originally compared. In not a few instances it may be considered wiser that the risks of slow healing, with suppuration and a tedious granulation process, should be encountered, rather than that a greater segment of the limb should be sacrificed. In many examples of amputation for injury in healthy men this is the case. Every inch of the limb is of value; the healing process may be slow, may involve much suppuration and a slow process of closure by granulation, but the patient is robust and well able to withstand the strain demanded, and in the end it proves that a portion of the limb has been saved at not too great a sacrifice.

In other examples—notably in operations for long-standing disease—ready healing of the stump is a matter of primary importance. The saving of a few inches of the limb is a matter of subordinate value. The patient is not in a condition to meet a vigorous suppurative process, and it may be evident that his life will be sacrificed before the healing process is complete.

The question is complicated by many side-issues.

In the case of amputation for injury, for example, where almost any danger in the future is anticipated to avoid the present sacrifice of a larger segment of the limb, the patient recovers after a tedious suppurative process with a stump so shrunken and so ill-covered that it is worse than useless, and he has to be content to remain a cripple or entertain a second amputation. In the case of amputation for disease also, it has

to be remembered that the higher the amputation the greater is the amount of shock and of immediate risk to life, and the carrying out of a high amputation to ensure speedy healing in a debilitated subject may involve an amount of shock which proves fatal.

As already said, the question is one of great difficulty, and can hardly be discussed apart from the actual case, every detail of which must in every instance be most carefully and patiently weighed.

3. **The Manner of the Operation.**—Much of the success of the amputation must obviously depend upon the manner in which it is done. Many evils may fall under this head. The flaps have been indifferently cut. They slough, or form so poor a covering to the bone that the edges of the wound have to be forcibly adjusted by the sutures. The muscles have been jagged, and large portions of muscular tissue nearly separated from the flap surface, and necessarily cut off from any sufficient blood supply, have been left to perish. The flaps have been roughly handled, have been dragged upon, and have been injured in uncouth efforts to expose the bone. Arteries have been slit up, or the main vessel of the flap has been wounded near the base of the flap.

Tendons are hanging loose in the depths of the wound, and are so far cut off from their normal vascular supply that they must perish by sloughing. Masses of tissue have been recklessly clamped in grasping bleeding vessels with the pressure forceps. The wound surface has been violently sponged, or the sutures have been applied before all hæmorrhage has been checked.

The soft parts about the bone have been lacerated by the saw, the periosteum has been extensively destroyed, and saw-dust from the bone has been ground into the mangled muscular tissue. The bone may have been splintered by forceps, and fragments of the shaft left in the wound. The assistant who has held the gangrenous limb during the amputation has—without washing his hands—held the main flap after the limb has been removed. To these possible evils must be added such as attend defective cleansing of the wound, imperfect securing of the vessels, and faults in the after-treatment.

CHAPTER IX.

The Mortality after Amputation.

1. **The General Mortality.**—Since the introduction of improved methods of performing amputation and of treating wounds, the general mortality after the operation has been very considerably reduced.

The more voluminous statistics published are of little value at the present day, since they deal with data afforded by older and much less successful forms of practice, and are largely composed of the returns of army surgeons. It is noteworthy also that the results shown by different statistics vary considerably.

Schede has compiled a table of 321 cases (occurring in civil practice) of amputations performed antiseptically, and attended by a mortality of only 4·4 per cent., while in 387 cases of amputation of equal importance treated during the pre-antiseptic period the mortality was 29·18 per cent.

One of the largest tables of statistics is that prepared by Ashhurst. He deals with 6,448 cases of amputation, the great mass of which belongs to the period before antiseptics. The mortality is given at 32·9 per cent. The statistics of the Newcastle-on-Tyne Infirmary, as prepared by Mr. Page, give in 10 years ending December, 1888, 484 cases of amputation, with a general mortality of 7·6 per cent. (*Lancet*, July 13th, 1889).

The statistics of St. Thomas's Hospital for the ten years 1876—1885 give a mortality of 12·8 per cent. for amputations of all kinds performed during that period.

MacCormac considers that this mortality "probably represents a fair average of the results attained in the London hospitals."

The statistics of 400 cases of amputation (occurring at St. George's Hospital between October, 1874, and June, 1888),

prepared by Mr. Dent, give a general mortality of 21 per cent. (*Med.-Chir. Trans.*, vol. lxxiii.).

2. **Influence of Age and Sex.**—Age has an important influence on the results of amputation. In the very young—those under the age of five years—it is not well borne, the mortality often being as high as between the ages of thirty-five and fifty. The mortality is lowest between the ages of five and fifteen. After fifteen the death-rate begins to steadily increase, although between the whole period of twenty to forty the variation is not very great. From fifty to sixty-five the mortality rapidly increases.

Ashhurst gives the following conclusions from his extensive collection of statistics:—(1) In persons under twenty years old the operation is a comparatively safe one, but in patients from twenty to forty it is nearly *twice*, and in those over forty not far from *three times*, as apt to be followed by death as during the earlier period. (2) In persons over thirty years of age amputation is almost twice as fatal as in those who are younger.

Mr. Dent's statistics give the following results:—

Age.	*Mortality.*
Under 5	12·5 per cent.
5 to 10	3·3 ,,
10 to 20	16·1 ,,
20 to 40	14·4 ,,
40 to 60	32·8 ,,
Over 60	70 ,,

Statistics show that the mortality of amputation is a little lower in women than in men. It must be remembered, however, that the cases of amputation in men are much more numerous, and include a larger proportion of operations for injury.

3. **Influence of the Cause of the Amputation.**—Amputations performed for disease are much less fatal to life than those performed for injury. The older statistics give out of a total of 6,448 amputations of all kinds a mortality of 39·8 per cent. in the operations for injury, and a mortality of 26·8 per cent. in the amputations performed for disease or deformity.

The records of the London Hospital for the last four years show the mortality after amputation of the leg or foot for

injury to have been 12 per cent., and for disease to have been 4 per cent.

MacCormac's statistics, dealing with 678 cases of amputation of all kinds performed during recent years, show the mortality after amputations for injury to be about 18·5 and for disease to be about 10·5 per cent.

Mr. Page's statistics, dealing with 484 like cases, give a mortality in cases of injury of 12·3 per cent., and in disease of 4·9 per cent. Mr. Dent's series of cases show a mortality of 15·2 per cent. in amputations for disease, and of 36·6 in amputations for injury.

Primary amputations for injury are less fatal than secondary amputations for injury. MacCormac gives the mortality of the former as 12·7 per cent., and of the latter as 24·2 per cent.; the death-rate being practically doubled.

4. **Influence of the Site of the Amputation.**—Amputations in the upper limb are less fatal than those in corresponding parts of the lower limb, and in either limb the rate of mortality increases the nearer the amputation is to the trunk.

The following table is founded on the statistics collected by Ashhurst and others, and upon the results of amputation as shown in the records of the London Hospital.

The figures are comparative only. The unit or standard is the mortality after amputation of the fingers or thumb, and is here expressed by the figure 1. For example, the mortality after amputations of the arm is nine times greater than that following amputation of the fingers (the standard), while that attending disarticulations at the knee is sixteen times higher than the death-rate of the standard amputation.

Fingers or thumb	1	Toes	2
Partial amputation of hand	2	Partial amputation of foot	7
Amputation at wrist-joint	4	Amputation at ankle-joint	5
,, of forearm	6	,, of leg	11
,, at elbow-joint	7	,, at knee-joint	16
,, of arm	9	,, of thigh	21
,, at shoulder-joint	12	,, at hip	24

CHAPTER X.

Amputation of the Fingers and Thumb.—General Considerations.

Anatomical Points.—The skin on the palmar aspect of the fingers and the thumb is thick, dense, stiff, and adherent. There is very little subcutaneous tissue. The palmar integument is remarkably sensitive, especially that covering the pulp of the digits.

The skin on the dorsum, on the other hand, is thin and loose, and beneath it is a stratum of lax connective tissue. Its sensibility is comparatively dull.

The position of the phalangeal joints must be clearly defined. It is to be borne in mind that the "knuckle" at both the metacarpo-phalangeal and inter-phalangeal joints is formed by the head of the proximal bone, and that the articular line is therefore beyond or below the knuckle. Of the transverse folds across the fronts of the fingers, produced by the joints, the highest is single for the index and little finger, and double for the other two. It is placed nearly three-quarters of an inch below the corresponding joint (Fig. 77). The middle folds are double for all the fingers, and are exactly opposite the first inter-phalangeal joints. The lowest creases are single, and are placed a little above the corresponding joints (from 1 to 2 m.m.). There are two single creases on the thumb corresponding to the two joints, the higher crossing the metacarpo-phalangeal articulation obliquely. The free edge of the web of the fingers, as measured from the palmar surface, is about three-quarters of an inch from the metacarpo-phalangeal joints (Fig. 77).

All the joints are supported by two lateral ligaments and a glenoid ligament. The former are nearer to the palmar than the dorsal aspect; the latter exists as a firm fibro-

cartilaginous plate, which is attached mainly to the base of the distal bone.

In the metacarpo-phalangeal joint of the thumb, two sesamoid bones replace this ligamentous palmar plate.

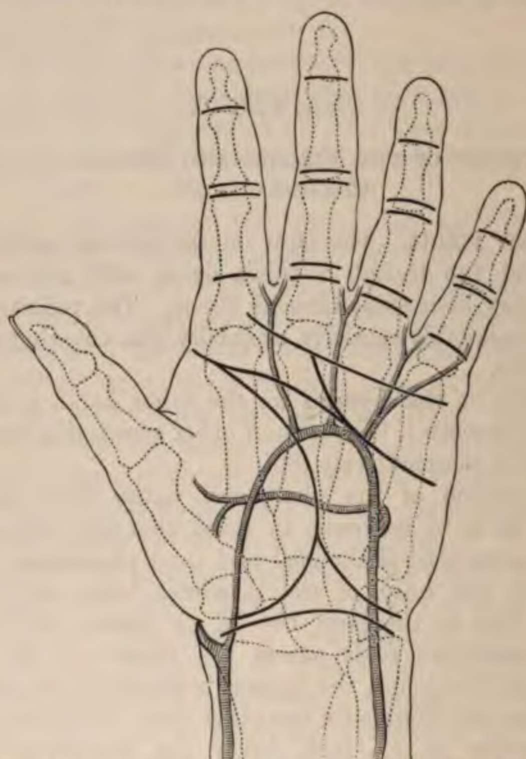

Fig. 77.—SURFACE MARKINGS ON THE PALM OF THE HAND. (The thick black lines represent the chief creases of the skin.)

A single epiphysis exists for each metacarpal bone and phalanx. It forms the head of the four inner metacarpal bones and the base of the metacarpal of the thumb and of the phalanges (Fig. 78). It joins the shaft at the age of twenty.

The fibrous sheaths for the flexor tendons extend from the metacarpo-phalangeal joints to the upper ends of the third phalanges. The pulp of the third phalanx, therefore, rests practically upon the periosteum. Opposite the finger-joints the sheaths are lax and thin. In the rest of their course they

are dense and rigid, and when cut across remain, in virtue of this rigidity, wide open, and form an open channel which leads into the palm of the hand (Fig. 79).

There are two synovial sacs beneath the annular ligament for the flexor tendons, one for the flexor of the thumb, the other for the two flexors of the fingers. The former extends up into the forearm for about 1¼ inch above the annular ligament, and follows the tendon to its insertion. The latter rises about 1½ inch above the annular band, and ends in diverticula for the four fingers. The process for the little finger usually extends to the insertion of the flexor profundus tendon in the last phalanx. The remaining three diverticula end about the middle of the corresponding metacarpal bones. The synovial sheaths for the digital part of the tendons to the index, middle, and ring fingers end above, about the neck of the metacarpal bones, and are thus separated by about half an inch from the great synovial sac beneath the annular ligament.

Fig. 78.—A FINGER FLEXED TO SHOW THE JOINT LINES AND THE EPIPHYSES.

Thus there is an open channel from the ends of the thumb and little finger to a point in the forearm some inch and a

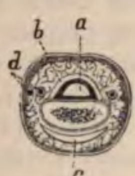

Fig. 79.—HORIZONTAL SECTION THROUGH THE MIDDLE OF THE SECOND PHALANX. (*Tillaux.*)

a, Flexor tendon; *b*, Fibrous sheath of tendon; *c*, Extensor tendon; *d*, Digital artery and nerve.

half above the annular ligament. Thus suppuration in the thumb and little finger is apt to be followed by abscess in the forearm, a complication unusual after a like trouble in the remaining fingers.

The digital arteries are about the size of the posterior auricular, and run much nearer to the palmar than the dorsal surface.

The dorsal digital arteries of the thumb are of good size, but on the fingers they appear as quite insignificant vessels which can hardly be traced beyond the first phalanx.

The Parts Removed.—Amputations of the fingers are often of necessity imperfect operations, and in some traumatic cases represent little more than a trimming of mangled parts.

In performing these operations every care should be taken to remove as little of the digit, and especially of the thumb and index, as possible. The shortest and most ungainly-looking stump of the thumb or of the forefinger may prove to be of the greatest value.

A French surgeon has well said, "Le pouce représente à lui seul l'un des mors de la pince que forme la main."

If the thumb or a portion of it be left, it is important that it should have something with which to come into apposition, and in fulfilling this need the slightest stump of the forefinger is of considerable service. The little and ring fingers are of less importance provided that the other digits remain; but in cases where the three or the two outer fingers have been removed, the little finger or the ring finger has been capable, in conjunction with the thumb, of performing most valuable and complex functions.

A hand with nothing left but the stumps of a thumb and of a little finger, is more useful than the most elaborate artificial limb. Dr. Gregory (*Trans. Amer. Surg. Ass.*, vol. ii., page 232) mentions the case of a lad who could hold a pen with a hand of which nothing had been saved but a small part of the thumb and the metacarpus and carpus.

The bone should always be divided as low down as possible. If only the base of the terminal phalanx can be saved, it will secure for the finger the attachment of the flexor profundus tendon.

Amputation of the second phalanx should be performed through the bone whenever possible. If the upper half, or even the upper third, of the phalanx be left, some portion of the insertion of the flexor sublimis will be saved. If, on the other hand, disarticulation is effected, the first phalanx is apt to be left to form a stump which is stiff and incapable of flexion, and is possibly an actual impediment.

This evil may be sometimes avoided by including the

flexor tendons in the sutures. "In the following special cases," writes Mr. Jacobson ("Operations of Surgery," page 4), "the whole or part of the first phalanx may be left, and in all of them the severed flexor tendons should be carefully stitched with carbolised silk to the cut theca and periosteum, or into the flaps themselves, before adjusting these.

"1. In the case of the index finger the proximal phalanx will be a useful opponent to the thumb, as in holding a pen.

"2. In the case of the little finger, leaving the proximal phalanx will give greater symmetry to the hand when this is flexed, and it should accordingly be left if the patient desire it.

"3. In cases of amputation of all the fingers, the proximal phalanx of one should, if possible, always be left to oppose the thumb.

"4. In the case of a patient who insists on having the proximal phalanx left, after the risk of stiffness has been explained to him, the more care is taken to fix the several flexors to the theca the more quickly the stump heals, and the younger the patient the greater will be the movement gained."

The Shaping of the Flaps.—As the bones of the finger are comparatively large in relation to the surrounding soft parts, the flaps must be cut comparatively long. Thus a single palmar flap should be equal to one diameter and a half of the digit. If unequal dorsal and palmar flaps are cut, the palmar flap should be longer than the diameter of the digit, while the dorsal flap should be about the third of the palmar. Farabeuf gives these measurements:—If the breadth of the finger be 16 m.m., a single palmar flap should be 24 m.m. in length. If unequal flaps be made, the palmar should measure 18 m.m. and the dorsal 6 m.m.

Flaps should be so cut that the cicatrix is removed from pressure. The scar therefore should not be on the extremity of the stump nor upon its palmar aspect. In other words, the scar is most conveniently placed when placed upon the dorsum.

For this reason a single palmar flap or a predominating palmar flap (when two are cut) represents the best method in amputation through the fingers. The stump which results is covered with firm and vascular skin, well able to withstand

pressure, and is indued with the remarkable sensibility of the part. A dorsal flap involves a covering for the stump which is thin, ill supplied with blood, little able to withstand pressure, and of slight sensibility.

The oval method provides a stump with the good qualities furnished by the palmar flap.

The Closing of the Fibrous Sheaths.—The fibrous sheaths for the flexor tendons when cut across, as in these operations, form rigid tubes along which pus may pass and enter the palm of the hand. The flexor tendons retract after division, but the sheaths do not, so there is provided in the depths of the stump a natural drainage-tube, the remote end of which leads into the palm; if no suppuration occurs, this hidden channel may produce no evil. It is soon occluded and unable to be harmful. If the stump, however, does suppurate, as is so common after crushes of the fingers, the pus can find its way with great readiness into the rigid patent fibrous tube, and then ensues that deep-seated suppuration in the stump and in the palm which is by no means uncommon after the present series of operations. When such a complication occurs, the pus can be squeezed out of the sheath, and, if the flaps have given way, can be seen to come from the tube itself.

To avoid this serious hindrance to healing, the fibrous sheath should be closed when possible after all amputations of the fingers and thumb. Over the terminal phalanx, and over the joint between the middle and terminal phalanges, there is no fibrous sheath. In front of the metacarpo-phalangeal joint it is scarcely evident. Over the first and second (proximal and middle) phalanges, and in front of the joint between these bones, the fibrous sheath is well marked, and appears as a rigid tube when cut across.

As the sheath crosses the metacarpo-phalangeal and first inter-phalangeal joints, it is adherent to the glenoid ligament, and is easily closed by two fine catgut sutures passed vertically, *i.e.*, from the dorsal to the palmar wall.

Opposite the shafts of the first and second phalanges, however, there is much difficulty in effecting this closure, since the sheath is united to the periosteum, and that membrane is very thin. In these situations the periosteum should be stripped up a little from the palmar aspect of the bone, and

the orifice of the tube secured by two fine sutures passed either vertically or transversely, as may appear the more convenient. This stripping off of periosteum should be effected before the bone is divided.

The Instruments required.—Narrow, slender, and strong scalpels, the blades of which should be equal in length to about one diameter and a half of the digit to be removed. (A fine scalpel with a cutting edge one inch in length will serve admirably for most amputations of the fingers. The "finger knife" of the instrument-makers is an absurd instrument. Its blade is, according to one catalogue, nearly three inches in length. Such large knives were at one time employed, and in Fergusson's figure of an amputation through the second phalanx, the knife depicted has a blade that must have been some four inches long.) A fine keyhole-saw or very small Butcher's-saw. Bone forceps. Dissecting and artery forceps. Tapes to hold aside the fingers. Scissors, needles, etc.

Fig. 80.—THE MODE OF HOLDING THE FINGER DURING DISARTICULATION OF THE LAST PHALANX.

Position.—The surgeon sits with the patient's hand before him. The limb should be in the position of pronation while dorsal incisions and flaps are being made, and in supination during the fashioning of palmar flaps.

In the oval operation the limb may be kept pronated throughout, and disarticulation is in any case conveniently effected in that position.

The surgeon holds the finger to be removed with his left hand, placed in the supine position (Fig. 80). An assistant is placed opposite to the surgeon. He holds the patient's hand in the required position, and keeps the sound digits out of the way.

CHAPTER XI.

Amputation or Disarticulation of the Phalanges of the Fingers.

These operations include amputations through the proximal, middle, or terminal phalanges, and disarticulations at the first or second inter-phalangeal joints. An amputation *through* the terminal phalanx can scarcely claim to be a defined operation.

Four methods will be described—

1. By single palmar flap.
2. By unequal dorsal and palmar flaps.
3. By single external flap.
4. By lateral flaps.

1. By Single Palmar Flap.—Illustrated by the removal of the last phalanx at the joint.

Hold the digit between the left thumb and forefinger (the thumb upon the pulp of the digit, the forefinger on the nail). Ascertain the position of the joint. Commence the incision upon one side of the finger opposite to the joint-line and midway between the dorsal and palmar aspects of the digit. (*See* Comment on these operations, page 327, paragraph 1.) Mark out the palmar flap by an incision which involves the skin only. This flap will include the greater part of the pulp of the finger (Fig. 81). Now carry the incision to the bone throughout, and dissect up the flap so freed, including in it everything down to the bone. (*See* Comment, page 327, par. 2.)

Let the patient's finger be now flexed, and make the dorsal incision. This incision is carried transversely across the finger at the level of the base of the distal phalanx. Retract the soft parts a little and open the joint. (*See* Comment, page 327, par. 3.)

Divide the lateral ligaments. Nothing now connects the phalanx with the rest of the finger but the flexor profundus

tendon and the glenoid ligament. Put the terminal phalanx in the position of extreme extension and divide these two structures, by cutting from below up against the base of that phalanx. (*See* Comment, page 327, par. 4.) No vessels require to be secured, and the tendon sheath is not opened.

2. **By Unequal Dorsal and Palmar Flaps.**—Illustrated by disarticulation at the first inter-phalangeal joint.

The palmar flap should exceed a little in length the diameter of the digit at the joint-line. The dorsal flap is one-third the length of the palmar (page 321). (*See* Fig. 81, C.)

Fig. 81.—A and B, Disarticulations by large palmar flap; C, Amputation by unequal dorso-palmar flaps.

Ascertain the line of the articulation.

Hold the finger in the position of pronation, and mark out the flaps by skin incisions. The flaps should be squarely cut. The lateral incisions should be placed midway between the dorsal and palmar surfaces, and should be commenced just above the joint-line.

Carry the lateral cuts to the bone. Flex the finger strongly and carry the dorsal incision to the bone.

Dissect up the dorsal flap, including in it all the soft parts to the bone. Open the joint from the dorsal aspect.

Dissect up the palmar flap, dividing the flexor tendon at the end of the flap while the finger is in the extended position. This flap also includes all the soft parts to the bone.

When the joint is reached, divide the lateral ligaments, separate the glenoid ligament from the base of the second phalanx, and the disarticulation is completed. (*See* Comment, page 327, par. 4.)

The tendon sheath must be closed (page 322).

If an attempt is to be made to secure the flexor tendons for reasons already given (page 321), the divided extremity of each (or the free end of the flexor profundus tendon only) is attached to the remains of the fibrous sheath and to the glenoid ligament (which is left in the stump). The tendons are thus made to occupy the fibrous sheath, which is readily closed around them.

No vessels will probably require ligature. The dorsal arteries are cut at the end of the palmar flap.

3. **By Single External Flap.**—Illustrated by disarticulation at the first inter-phalangeal joint.

The flaps are fashioned as shown in Fig. 82, A. The two longitudinal incisions are in the centre of the dorsal and palmar surfaces respectively, and both commence just above the level of the joint.

The outer transverse incision—marking the extremity of the external flap—is opposite the centre of the second phalanx. The inner transverse incision is opposite the joint.

The external flap, having been marked out, is dissected up. It contains all the soft parts down to the tendons.

The finger having been fully flexed, the joint is opened from the dorsum by cutting through the extensor expansion.

The lateral ligaments of the joint are now cut.

The finger is then placed in the position of extension, and the flexor tendons and the attachment of the glenoid ligament are divided from below up against the base of the second phalanx.

The tendons and the tendon-sheath may be dealt with as in the previous operation.

The digital vessels are divided in the transverse incision, but will probably not require ligatures.

4. **By Lateral Flaps.**—Illustrated by amputation through the second phalanx.

The external and internal flaps are of equal size and do not equal in length the diameter of the finger (Fig. 82, B). The dorsal and palmar incisions are median. The flaps are squarely cut and contain all the soft parts down to the tendons. The flexor profundus tendon and the expansions from the flexor sublimis and extensor tendons are divided circularly at the saw-line. The bone is divided with a fine saw. (*See* Comment, page 328, par. 5.)

The digital arteries are cut at the extremities of the flaps.

Appreciation of the above Operations.—Of these four procedures the two first-named are the best. The importance of the palmar flap has already been dwelt upon (page 321).

The third method—that by an external flap—answers well when the tissues upon the palmar and inner sides of the

well suited to some amputations of the inner

nputation by the lateral method produces well- flaps and a shapely stump, but the cicatrix is ently placed; and if the healing be imperfect, there is on for the bone to project between the flaps.

palmar and dorsal flaps produce a stump with the its extremity.

ral method is not well adapted for these amputa- applied to effect a disarticulation, the dorsal hould commence just above the joint, and the ncision be about the centre of the phalanx below). The resulting stump is clumsy, and the cicatrix d.

ent upon the above Operations.—1. A longitudinal in the centre of the lateral surface of the finger way between the dorsum and the palmar aspect— round the digital artery, which will be found intact nar flap.

no operations upon the fingers is it well to cut the ansfixion. In cutting a palmar flap by this means anger of slitting up the digital arteries. The flap, is apt to be pointed and scanty, and to contain of tendon.

isarticulations a very slight dorsal flap is a decided and allows a better covering to be provided for f the bone.

rticulation may be effected in finger amputations from above downwards. The joint is exposed from m, the finger being fully flexed; the lateral liga-

phalanx often offers an obstacle to the passage of the knife; the glenoid ligament—which should be left in the stump—is apt to be cut away, and damage may be inflicted upon the tissues of the palmar flap.

5. A very fine saw is much to be preferred to the bone-forceps for dividing the phalanx. The forceps are apt to splinter the bone, especially in the fingers of well-developed adults and in old persons (page 306).

CHAPTER XII.

Disarticulation of Fingers at the Metacarpo-Phalangeal Joints.

These operations are performed with great frequency and represent the most common amputations of the fingers.

It is well that the cicatrix should come upon the dorsum of the hand, and that the operation should be so carried out as to involve the least possible interference with the palm.

The following methods will be described:—

1. By the oval method.
2. By lateral flaps.
3. Operations for the forefinger.
4. Operations for the little finger.

1. By the Oval or Racket Method.—The method here described corresponds to the French *incision en croupière*, and does not exactly accord with either the orthodox racket incision or the unmodified oval operation.

The dorsal incision is commenced just above the head of the metacarpal bone (*i.e.*, opposite to its neck), and is carried down in the median line of the finger until it has passed the base of the phalanx.

The cut now divides, and its limbs sweep obliquely across each side of the root of the finger. They are joined on the palmar aspect by a transverse incision, which exactly follows the crease between the finger and the palm, and is therefore level with the free margin of the web (Fig. 82, F).

The surgeon, having made out the position of the joint, holds the finger in the prone position in his left hand. An assistant steadies the hand and keeps the other fingers out of the way.

Throughout the whole operation the limb is kept in the prone position.

The knife is entered upon the dorsum, and is carrie across one side of the root of the finger and then acr other side. The incision is completed by the tra palmar cut. Three separate cuts with the knife are th required.

There is no object in attempting to make the enti sion with one sweep of the scalpel.

The incision should at first involve the skin only.

The finger is now extended to its utmost, and the incision is carried bone, the flexor t being thus stretch divided.

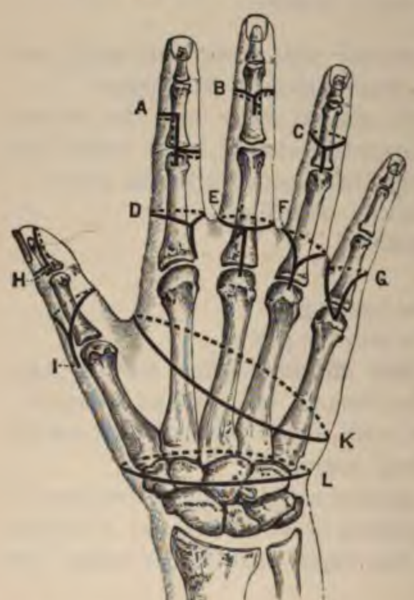

Fig. 82.—A, Disarticulation by single external flap; B, Amputation by lateral flaps; C, Disarticulation by oval or racket incision; D, Modified racket incision for index finger; E, Circular method, with vertical dorsal cut; F, Incision *en croupière*; G, Interno-palmar flap method for little finger; H, Disarticulation by single palmar flap; I, Disarticulation by racket incision; K, Amputation of the fingers with their metacarpal bones; L, Circular disarticulation at the wrist.

The finger bein turned to one or side, the lateral in —on each aspect root of the finge carried to the bon this way the digi teries are cleanly di and the expansions the lumbricals and ossei are cut.

The assistant takes the finger, whi surgeon dissects bac flaps, as far as the j line, with the ai forceps.

The wrist and f being fully extended operator once more hold of the digit and ceeds to open the from the palmar as He cuts the glenoid ment transversely against the base of the phalanx, divide lateral ligaments, and finally completes the operatio cutting the extensor tendon. Disarticulation may be eff

from the dorsum, but it renders the section of the glenoid ligament a little less easy.

The synovial sheath for the flexor tendons may be closed.

The glenoid ligament remains in the stump.

The two palmar digital arteries will require to be ligatured or twisted.

The cicatrix is vertical—*i.e.*, in the long axis of the limb.

2. **By Lateral Flaps.**—The method here described is that often known as Lisfranc's operation.

The flaps are of equal size and are a little rounded. The base of each corresponds to the joint-line, the free extremity of each to the level of the web. The median dorsal cut commences just above the metacarpo-phalangeal joint. The palmar median incision extends into the palm up to the level of that joint (Fig. 83, B).

The *modus operandi* is as follows:—

The surgeon marks out both the flaps by skin incisions. He then dissects up one of the flaps (that to his right) until the joint is reached. This flap includes all the soft parts down to the bone, and the digital artery is divided at its free extremity.

He then opens the joint by cutting the exposed lateral ligament, viz., that to his (the surgeon's) right.

Holding the knife vertically, with the blade directed upwards, the operator passes it across the joint, cuts the opposite lateral ligament, and then fashions the other lateral flap (that to the surgeon's left) by cutting from within outwards.

All the tendons are divided at the joint-level, and are severed as the knife is passed transversely across the articulation.

The digital vessels are cut at the free end of each flap.

3. **Modified Operations for the Forefinger.**—In order that the cicatrix may not be exposed to pressure when the thumb is opposed to the stump, or when anything is being held in the hand, the following modified procedures may be carried out:—

(*a*) By the racket incision, with the vertical cut placed upon the side of the index nearest to the middle finger, and with the incision carried a little further on the radial than

on the ulnar side of the digit. In the latter situation it corresponds to the web (Fig. 82, D).

(*b*) By unequal lateral flaps, the external flap being the larger.

(*c*) By the externo-palmar flap of Farabeuf. The incision commences at the joint-line, just to the radial side of the extensor tendon. It is carried down along the outer side of the dorsum nearly as far as the centre of the shaft of the phalanx. It is then made to sweep across the palmar aspect of the finger to the web. From the web it passes by the shortest route to the point at which the incision commenced (Fig. 83, A).

The large flap is dissected up, carrying with it all the soft parts down to the bone. The tendons are divided and disarticulation effected in the usual way.

4. **Modified Operations for the Little Finger.**—These have for their object the removal of the cicatrix from an exposed position.

(*a*) By a racket incision, with the vertical cut placed upon the side of the digit nearest to the ring-finger, and with the incision carried a little further on the ulnar than on the radial side of the finger.

(*b*) By unequal lateral flaps, the internal being the larger.

(*c*) By the interno-palmar flap of Farabeuf (Fig. 82, G). It corresponds to the flap already described as employed for the index finger, with the necessary difference that the position of the incisions is transposed.

Comment on the above Operations.—In all these disarticulations, the head of the metacarpal bone should be spared whenever possible.

It is unreasonable to sacrifice it simply on the ground that—in a particular case—the covering of soft parts is scanty. It is better, in such an instance, that the necessarily gaping wound should be allowed to granulate over than that the end of the bone should be removed.

It is still more unreasonable to sacrifice it on the ground that its removal improves the aspect of the mutilated hand. The appearance of the part may certainly be improved at the moment of the operation, but in the course of time the unnaturally narrow extremity does not compare favourably

with the hand marked by an unduly wide gap between the fingers.

The head of the bone, if left, appears to waste. The soft parts about it certainly waste; and if the hand be inspected six months after the disarticulation, it will seldom be evident that the removal of the head of the bone would have led to an improvement in the appearance of the part.

The excision of the head weakens the hand greatly, an effect due, probably, to a severing of the connections of the transverse ligament. Its removal involves, moreover, an undesirable opening up of the tissues of the palm.

Of the two operations first described, the better is undoubtedly that by the racket incision. The cicatrix in this operation is well placed, and the tissues of the palm are not disturbed. The edges of the wound come fairly well together, but a little pocket is apt to be left in the palmar tissues just in front of the head of the metacarpal bone, in which pouch pus may collect.

The operation by lateral flaps has the advantages of affording a good covering to the bone, a wound that can be neatly approximated, without allowing any "pocket" to be formed, and consequently good drainage. It has two great drawbacks, however: the cicatrix is carried into the palm, and the tissues are of necessity opened up.

The method by means of a circular incision at the level of the web, with a median dorsal cut (Fig. 82, E), affords a most excellent covering to the bone, but it provides a somewhat clumsy stump.

The various operations for the index and little fingers call for no especial comment. Farabeuf's methods by intero-palmar or externo-palmar flaps are probably the best, while the method of unequal lateral flaps is the least to be advised.

CHAPTER XIII.

Amputations and Disarticulations of the Thumb.

In performing an operation through the first or the second phalanx, or in disarticulating at the inter-phalangeal joint, one or other of the methods already described in Chapter XI. may be employed (Fig. 82, H and Fig. 83, C).

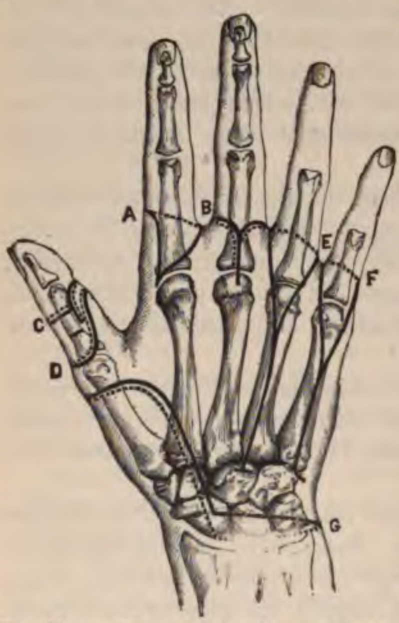

Fig. 83.—A, Disarticulation by special externo-palmar flap; B, Disarticulation by lateral flaps; C, Amputation by unequal dorso-palmar flaps; D, Disarticulation by oblique palmar flap; E, Disarticulation of the ring finger, with its metacarpal bone, by racket incision; F, Same operation upon the little finger; G, Dubrueil's disarticulation at the wrist.

The comments applied to these operations apply equally when they concern the thumb. In any amputation below the inter-phalangeal joint the sheath for the flexor tendon should be closed. There are four digital arteries to the thumb, and two at least of these will probably need to be secured.

Disarticulation at the Metacarpo-phalangeal Joint.—It may be remembered that the extensor primi internodii pollicis, the abductor and the adductor pollicis, and the flexor brevis pollicis, all find insertion into the base of the first phalanx.

The methods described in the previous chapter apply in general terms to this dis-

articulation. The two most suitable operations are the following :—

1. *By the Racket Incision.*—The incision commences upon the dorsum, opposite the neck of the metacarpal bone, and is continued down along the line of the extensor tendon until the base of the first phalanx is passed. Here the incision divides to form the oval, the palmar cut crossing the thumb transversely about opposite to the centre of the shaft of the phalanx (Fig. 82, I).

The steps of the operation have been already described (page 329). Disarticulation may be effected from the dorsum.

The two extensor tendons are divided opposite to the joint-line. The flexor longus pollicis tendon may be severed opposite to the palmar incision, and the extremity of the tendon may be attached to the sesamoid bones. The latter structures should be carefully detached from the base of the phalanx and are left in the stump.

The sheath for the long flexor tendon should be entirely closed. Two or more digital vessels will probably require ligatures.

2. *By Oblique Palmar Flap.*—This is Farabeuf's method. It is most excellent in cases where the tissues permit of so large a flap being cut.

The dorsal incision is U-shaped, the concavity being towards the nail, and the bend of the U opposite to the joint-line.

The palmar incision is U-shaped, the convexity being towards the nail, and the bend reaching nearly to the inter-digital fold in the skin. The lines of the cut follow the lateral borders of the thumb (Fig. 83, D). The flap is dissected up in the usual way. The extensor tendons are divided opposite to the joint, and the long flexor about the middle of the phalanx. The operation is finished in the manner already described.

CHAPTER XIV.

Amputations of the Fingers and Thumb, together with Portions of the Metacarpus.

These operations include the partial or complete removal of one or more metacarpal bones, together with the corresponding digit or digits. They are seldom performed in their entirety in actual practice. There are but few conditions in either injury or disease which could render them possible. The least infrequent of these operations concern the amputation of the thumb, with its metacarpal bone, and the removal of crushed fingers, together with such part of the metacarpus as is hopelessly damaged.

As dead-house operations, the procedures here described form very admirable exercises.

In this part of the hand the rule still holds good that every portion and fragment of tissue should be spared whenever possible.

Anatomical Points.—The main dangers of these operations consist in possible damage inflicted upon the tissues of the palm, in wounding the deep palmar arch or the termination of the radial artery, and in opening up the general synovial sac of the carpus, or the scarcely less important synovial sac about the flexor tendons beneath the annular ligament.

The surface markings on the palm of the hand should be called to mind, together with their relations to the metacarpal bones and the palmar arches (Fig. 77). The great crease produced by the apposition of the thumb is very noteworthy. The lowest transverse crease on the palm crosses the necks of the metacarpal bones, and indicates pretty nearly the upper limits of the synovial sheaths for the flexor tendons of the three outer fingers. A little way below this fold the palmar fascia breaks up into its four slips, and midway between the

fold and the webs of the fingers lie the metacarpo-phalangeal joints.

The aspect of the carpo-metacarpal line of joints—from the dorsum—is to be observed; the saddle-shaped surface of the base of the first metacarpal bone as it articulates with the trapezium; the V-shaped articular line between the metacarpal of the index and the trapezoid; the remarkable projection (styloid process) from the base of the third metacarpal bone at its dorsal and radial aspect, and the comparative simplicity of the joints connecting the two inner bones with the unciform.

The base of the metacarpal bone of the thumb is formed by an epiphysis which joins the shaft at about twenty.

A separate and isolated synovial cavity separates both the first metacarpal and the fifth from their respective carpal bones. The remaining metacarpals are separated from the carpus by the common synovial sac of the hand.

The joint between the thumb and the trapezium is provided with a distinct capsule.

The bases of the four inner metacarpals are united by transverse dorsal, palmar, and interosseous ligaments.

A strong and special interosseous band passes between the os magnum and unciform and the bases of the third and fourth metacarpal bones.

To the base of the first metacarpal is attached the extensor ossis metacarpi pollicis; to the base of the second the extensor carpi radialis longior and the flexor carpi radialis; to the base of the third the extensor carpi radialis brevior; and to the base of the fifth bone the extensor carpi ulnaris and some fibres of the flexor carpi ulnaris.

To the shafts of all the bones some portions of the interossei muscles are attached, and into the shafts of the metacarpals of the thumb and little finger are inserted in addition the corresponding opponens muscle.

The joint of the thumb is easily defined on movement. In removing the metacarpal bone of that digit, the details of the *tabatière anatomique* should be called to mind. The space so named is bounded by the extensor secundi internodii pollicis on the one side, and the extensores ossis metacarpi and primi internodii on the other.

In its floor are the scaphoid, the trapezium, and the carpo-metacarpal joint of the thumb. The extensor secundi tendon just crosses the apex of the first interosseous space. The radial artery runs over the floor of the *tabatière* and passes through the apex of the interspace to reach the palm.

The position of the synovial sheaths of the flexor tendons has been already indicated (page 319).

The deep palmar arch crosses the shafts of the second, third, and fourth metacarpal bones close to their bases (Fig. 77).

Each digital artery bifurcates a little more than one quarter of an inch above the free edge of the web of the finger.

Instruments.—A stout narrow scalpel with a blade about 1½ inch long will suffice for the oval methods, and a slender bistoury, with a cutting edge of some 9 inches, is required for transfixion operations. A fine keyhole-saw. Small retractors. Bone-forceps. An elevator, if the periosteum is to be preserved. Dissecting and artery forceps. Scissors, needles, etc.

Position.—The surgeon sits with the patient's hand before him. The limb should be in the position of pronation. The operator grasps the finger to be removed, keeping his hand supine. An assistant, placed opposite to the surgeon, holds the patient's hand in the required position, and keeps the sound digits out of the way.

The following procedures will be described :—

A. Partial amputations.
B. Disarticulation of a finger with its metacarpal bone.
C. Disarticulation of the thumb with its metacarpal bone.
D. Amputation of several fingers with their metacarpal bones.

A. **Partial Amputations.**—As much of the metacarpus should be preserved as is possible. In such partial operations the deep palmar arch is not exposed to the risk of being wounded: the attachments of certain tendons are preserved, the carpo-metacarpal synovial sacs are not opened up, and if the bone be divided beyond its centre the synovial sacs of the flexor tendons may escape the knife in the case of the three middle digits.

The racket method should be employed. The vertical incision follows the median dorsal line of the metacarpal,

while the oval cut traverses the web and follows the transverse digito-palmar crease.

The general features of the operation are the same as in the complete disarticulations (*vide infra*).

The dorsal incision should be commenced a little way above the point at which it is intended to divide the bone.

The bone should be severed with a saw whenever possible, the soft parts being protected by a director during the passage of the instrument. The shaft is apt to be much crushed if bone-forceps are employed.

The second and fifth metacarpals should be divided obliquely, so that the end of the bone may not project unduly upon the margin of the hand.

B. **Disarticulation of a Finger with the corresponding Metacarpal Bone.**—The racket incision is conveniently employed. The operation may be illustrated upon the ring finger (Fig. 83, E). The joint line having been made out, the *queue* of the racket is commenced just above the articulation, and is carried down along the dorsum of the metacarpal until the base of the knuckle is reached.

The incision here divides, and the oval wound, following the clefts between the fingers, crosses the web and terminates transversely at the digito-palmar crease in the skin.

The incision involves at first the skin only, the surgeon holding the finger and manipulating it as required with his left hand.

An assistant now takes charge of the finger while the surgeon deepens the dorsal incision and divides the extensor tendons just beyond the base of the bone.

The sides of the shaft of the metacarpal are now bared from one end to the other, the knife being kept very close to the bone. During this step the surgeon uses his left finger to assist in the separation of the interossei from the shaft, the assistant rotating the digit as required.

The knife is carried back between the bases of the metacarpal bones (on either side of the bone to be removed), so as to divide the interosseous ligaments; the skin is at the same time retracted, so as to expose the part. To more conveniently reach the articulation, a transverse cut may be made at the end of the vertical incision (Fig. 83, E).

In its floor are the scaphoid, the trapezium, and the carpo-metacarpal joint of the thumb. The extensor secundi tendon just crosses the apex of the first interosseous space. The radial artery runs over the floor of the *tabatière* and passes through the apex of the interspace to reach the palm.

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Each digital artery bifurcates a little more than one quarter of an inch above the free edge of the web of the finger.

Instruments.—A stout narrow scalpel with a blade about 1½ inch long will suffice for the oval methods, and a slender bistoury, with a cutting edge of some 9 inches, is required for transfixion operations. A fine keyhole-saw. Small retractors. Bone-forceps. An elevator, if the periosteum is to be preserved. Dissecting and artery forceps. Scissors, needles, etc.

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D. Amputation of several fingers with their metacarpal bones.

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The racket method should be employed. The vertical incision follows the median dorsal line of the metacarpal,

while the oval cut traverses the web and follows the transverse digito-palmar crease.

The general features of the operation are the same as in the complete disarticulations (*vide infra*).

The dorsal incision should be commenced a little way above the point at which it is intended to divide the bone.

The bone should be severed with a saw whenever possible, the soft parts being protected by a director during the passage of the instrument. The shaft is apt to be much crushed if bone-forceps are employed.

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The incision here divides, and the oval wound, following the clefts between the fingers, crosses the web and terminates transversely at the digito-palmar crease in the skin.

The incision involves at first the skin only, the surgeon holding the finger and manipulating it as required with his left hand.

An assistant now takes charge of the finger while the surgeon deepens the dorsal incision and divides the extensor tendons just beyond the base of the bone.

The sides of the shaft of the metacarpal are now bared from one end to the other, the knife being kept very close to the bone. During this step the surgeon uses his left finger to assist in the separation of the interossei from the shaft, the assistant rotating the digit as required.

The knife is carried back between the bases of the metacarpal bones (on either side of the bone to be removed), so as to divide the interosseous ligaments; the skin is at the same time retracted, so as to expose the part. To more conveniently reach the articulation, a transverse cut may be made at the end of the vertical incision (Fig. 83, E).

The operator now carries the knife forward through the tissues of the web on either side of the finger, and, the digit being fully extended, the palmar incision is carried down to the flexor tendons.

The assistant then holds the finger in the position of the extremest extension, while the surgeon lays bare the under-surface of the flexor tendons, which he ultimately divides opposite the neck of the shaft.

While the finger is still extended to the utmost, the operator exposes the palmar surface of the bone as well as is possible and as far back as is possible.

The ligaments of the joint having been divided, the finger is turned back upon the dorsum of the hand, and the last structures divided are such resisting palmar structures as still remain, together with the tendon of the extensor carpi radialis brevior.

The digital arteries are divided in the tissues of the web.

The synovial sheath of the flexor tendons should be closed with fine catgut sutures, if possible.

In the case of the *index finger* the vertical incision should be carried along the dorsum of the bone rather than along its radial side, as sometimes advised. A transverse cut should be made over the trapezoid at the end of this incision.

In removing the *little finger* with its metacarpal bone, the dorsal incision should be placed rather towards the inner side of the shaft of the bone, and from its extremity a short transverse cut may be made towards the ulnar margin of the hand (Fig. 83, F).

In clearing the bone it is convenient to have the patient's elbow held upon the table by an assistant, who at the same time flexes the forearm until it is nearly vertical, and well abducts the finger to be removed.

The metacarpal is removed laterally, and is not turned up upon the dorsum of the hand. During its removal it is made to assume the position of the extremest abduction.

The operation by lateral internal flap cut by transfixion is to be condemned. It has no advantages, and involves a scar upon both the dorsal and palmar aspects of the hand.

C. **Disarticulation of the Thumb, together with its Metacarpal Bone.**—In this operation especial care must be taken

not to wound the radial artery as it passes close to the base of the metacarpal bone to reach the palm, and not to open the joint between the metacarpal of the index and the trapezoid.

One of the two following methods may be employed :—

1. *The Racket Method.*—The hand is to be held in the mid-position between pronation and supination. The wrist is steadied by an assistant while the surgeon holds the thumb.

The dorsal incision commences in the *tabatière,* just above the carpo-metacarpal joint, and on the tendon of the extensor primi internodii pollicis. It runs along the dorsum of the thumb, keeping nearer to the external than the internal border of the metacarpal bone.

The oval encircles the head of that bone and crosses the palmar aspect of the digit on a level with the free edge of the web as displayed when the thumb is abducted (Fig. 84).

Fig. 84.—DISARTICULATION OF THE THUMB WITH ITS METACARPAL BONE BY A RACKET INCISION.

The incision at first involves the skin only, and the operator himself holds and manipulates the member while the racket is being made.

An assistant now takes the thumb, and the surgeon proceeds to deepen the dorsal incision to the bone, cutting the extensores primi and secundi as high up as possible.

The dorsal surface of the bone and each side of it are then bared of soft parts as far as can be effected from the dorsum.

The knife must throughout be kept close to the bone.

The thumb is now forcibly abducted. The palmar incision is deepened. The muscles attached to the base of the first phalanx are divided close to the sesamoid bones.

The thumb being turned and rotated from side to side by the assistant as required, the palmar surface of the meta-

carpal is cleared, the knife being kept close to the bone. The long flexor tendon may be divided about the middle of the metacarpal bone.

The operator once more takes hold of the thumb, and wrenching it from side to side as needed, effects the disarticulation.

Probably the last structure divided is the tendon of the extensor ossis metacarpi pollicis.

The sheath of the flexor tendon should be closed if possible.

The arteria princeps pollicis, or its two collateral branches, will be found divided on the palmar aspect of the wound and will require a ligature. The vessel runs along the palmar side of the metacarpal bone, and bifurcates between the heads of the flexor brevis and under cover of the long flexor.

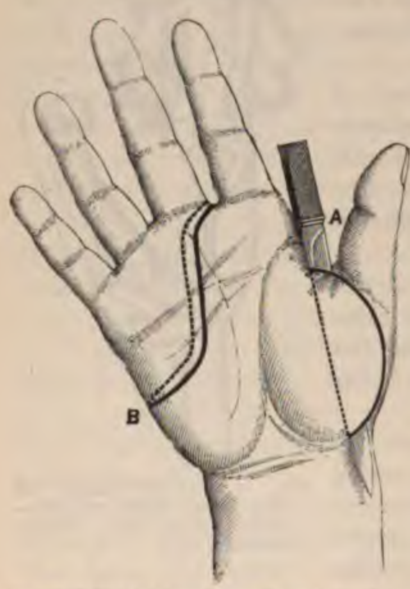

Fig. 85.—A, Disarticulation of the thumb with its metacarpal bone by palmar flap: B, Amputation of the three inner fingers with their metacarpal bones.

The two dorsal arteries of the thumb are small and may not require to be secured.

2. *By Palmar Flap.*—This operation may be rapidly performed, but it is decidedly inferior to the method just described. A considerable section of the muscular tissues is made; there is greater danger of wounding the radial in the palm and of opening a carpal joint. The flap is cut by transfixion, and the operation is thus detailed by Sir William MacCormac:—

"An assistant should grasp the finger while the surgeon abducts the thumb. The knife, introduced into the centre of the web, and passed towards the trapezium, beneath the muscles of

the thumb, is made to emerge at the base of the metacarpal bone, and then by cutting outwards a rounded flap is formed, comprising the whole of the tissues of the ball of the thumb (Fig. 85, A). The extremities of this flap are now united by a straight incision across the dorsal aspect, the thumb being still held strongly abducted, the remaining soft tissues are divided, the joint opened on the inner side, and the disarticulation completed.

"The flap may be formed by introducing the knife at the base of the metacarpal bone, and bringing it out at the centre of the web. This is preferable on the left side."

D. **Amputation of several Fingers, together with their Metacarpal Bones.**—These operations cannot be systematised, and the majority of the procedures which figure in French manuals must be regarded merely as ingenious dead-house operations.

These amputations concern for the most part cases of crush of the hand and of frost-bite, in which the least amount of tissue is sacrificed, and in which definite flaps can seldom be cut or definite incisions followed.

The following may be briefly cited as methods which are at least theoretically suitable:—

1. *Amputation of the Two Inner Fingers and their Metacarpal Bones.*—The racket method may be employed. The dorsal incision commences on the outer side of the base of the fifth metacarpal, and after following the fourth interosseous space but about one inch it divides, one limb dividing the web between the middle and ring finger, and the other crossing the knuckle of the little finger on its inner side. The two extremities of this Y-shaped incision are joined by a transverse palmar cut following the palmo-digital creases.

2. *Amputation of the Three Inner Fingers with their Metacarpal Bones.*—The knife follows the lines shown in Fig. 85, B. The incision commences a little way below the base of the fifth metacarpal, runs downwards and outwards across the palm below and parallel to the main transverse crease. It is then directed towards the base of the middle finger, and finally divides the web to the outer side of that digit. A similar incision is made upon the dorsum, and in this way equal dorsal and palmar flaps are made.

3. *Amputation of all the Fingers with their Metacarpal Bones.*—Here a short palmar flap may be made. The lines of the incisions are shown in Fig. 82, K. The dorsal wound is concave forwards, the palmar wound convex.

Some surgeons cut the palmar flap by transfixion.

In any of the operations named the metacarpal bones may be sawn through near their bases, or may be completely removed by disarticulation.

AFTER-TREATMENT OF AMPUTATION OF THE FINGERS AND THUMB.

The wounds after these operations as a rule heal well. Portions of divided tendons may slough, and pus may find its way along the sheaths of the tendons when those canals have not been closed.

As the skin of palmar flaps is usually thick and stiff, the sutures should be well applied, and should not be too soon removed. Silkworm-gut sutures are well adapted for these operations.

The hand should be kept elevated, and never allowed to hang down, and care must be taken that too tight bandages are not applied about the wrist.

In the larger operations, especially where a palmar flap has been cut, the hand should be supported upon a splint in order to arrest the movements of the wrist.

As a rule no drainage-tube is required; but when the metacarpus is concerned, and when the tissues of the palm have been lacerated or opened up, a tube may with benefit be introduced and retained for some twenty-four or forty-eight hours.

The partial operations following upon crushes of the hand must be treated upon the same principles as apply to complicated wounds.

CHAPTER XV.

DISARTICULATION AT THE WRIST-JOINT.

OPPORTUNITIES for the performance of this operation are not common.

In cases of injury the soft parts may, on the one hand, be so extensively damaged as to involve amputation of the forearm; or the lesion may, on the other hand, be so limited as to make it possible to save the carpus or a part of the metacarpus, with possibly a finger.

In cases of disease of the carpal bones requiring amputation, the skin about the wrist is usually so involved and so penetrated by sinuses that the limb has to be removed higher up.

As, moreover, the movements of pronation and supination have probably been lost during the progress of the disease, there is less reason for disarticulation in these cases.

The operation has been performed in instances in which excision of the wrist has failed.

Anatomical Points.—The styloid process of the radius lies more anteriorly than does the corresponding process of the ulna, and also descends nearly half an inch lower down the limb. Most of the tendons about the wrist can be made out through the skin. The palmaris longus tendon is nearly opposite to the centre of the wrist in front. A little to its outer side is the larger but less prominent tendon of the flexor carpi radialis. In the groove between these two tendons lies the median nerve. Of the tendons at the back of the wrist, the most conspicuous is that of the extensor secundi internodii pollicis. It leads up to a small, bony elevation at the back of the radius, which serves to indicate the centre of the posterior surface of that bone, and also the position of the interval between the scaphoid and semilunar bones.

When the hand is supine, the styloid process of the ulna is

exposed at the inner and posterior aspect of the wrist, to the inner side of the extensor carpi ulnaris. In pronation, however, the process is rendered indistinct, while the head projects prominently on the posterior part of the wrist, and is found to lie between the tendons of the extensor carpi ulnaris and the extensor minimi digiti.

The tip of the styloid process of the ulna forms the best guide to the wrist-joint. A knife introduced below that point of bone will enter the articulation. A knife entered horizontally just below the tip of the radial styloid process will hit the scaphoid bone.

A line drawn between the two styloid processes slopes downwards and outwards, and represents the extreme inferior limits of the radio-carpal joint, while it is at the same time nearly half an inch below the summit of the arch of that articulation.

Of the several folds in the skin on the front of the wrist, the lowest is the most distinct (Fig. 77). It is a little convex downwards, crosses the neck of the os magnum in the line of the third metacarpal bone, and is nearly three-quarters of an inch below the arch of the wrist-joint. It is about half an inch above the carpo-metacarpal joint-line, and indicates very fairly the upper border of the anterior annular ligament.

The skin on the dorsum of the wrist is thin, and the subcutaneous tissue is scanty and very lax. The integuments, as a consequence, retract very considerably when divided. Farabeuf states that 3 c.m. should be allowed for this retraction, which he characterises as enormous.

The bony eminences formed by the tubercle of the scaphoid and the ridge of the trapezium on the one side, and the pisiform bone and the unciform process on the other, should be defined. The anterior annular ligament, which is about the size and shape of a postage-stamp, extends between them, and bridges over the hollow in which the main tendons run.

The position and extent of the synovial sheaths for the flexor tendons have been already alluded to (page 319).

Beneath the posterior annular ligament are six synovial tendon-sheaths. The sheaths for the extensors of the metacarpal bone and first phalanx of the thumb and for the radial extensors reach some three-quarters of an inch above the radial

styloid process. The remaining sheaths extend only to the upper margin of the annular ligament.

The position of the palmar arches must be borne in mind. The deep branch of the ulnar artery arises immediately below the pisiform bone. The radial, to reach the back of the wrist, crosses the external lateral ligament of the wrist upon which it rests.

The wrist-joint has a separate synovial sac.

The synovial sheath of the extensor minimi digiti sometimes communicates with the inferior radio-ulnar joint.

Of the ligaments of the wrist the anterior is the strongest, while the posterior is the most feeble.

Instruments.—A narrow amputating-knife, with a stout handle, and a blade from three to four inches in length. A scalpel. Dissecting and artery forceps, scissors, needles, etc.

Position.—The surgeon sits facing the patient's forearm, which is abducted horizontally, and with the hand pronated. An assistant stands facing the operator, and with his back to the patient's shoulder. He steadies the limb, draws up the soft parts, and takes charge of the flaps as they are formed. He can also manipulate the hand if required. A second assistant may conveniently attend to the sponging.

The following methods of disarticulating will be described :—

1. Circular.
2. By elliptical incision.
3. By long palmar flap.
4. By external flap (Dubrueil's operation).

1. **The Circular Method.**—The circular incision is some way below the joint, and is inclined a little lower down upon the radial than upon the ulnar side, in order that the outer styloid process may be well cleared.

The incision on the inner side is just above the base of the fifth metacarpal bone, while on the outer side it crosses the first metacarpal about 1 c.m. below the carpo-metacarpal joint of the thumb (Fig. 82, L and Fig. 86, A).

The surgeon, holding the patient's hand in his left hand, makes the circular incision, commencing it upon the dorsum, and turning the hand from the prone to the supine position as the knife travels round the limb.

The incision concerns at first the skin and the subcutaneous tissues only, and as it is being made the assistant draws up the soft parts of the dorsum.

The hand is now allowed to drop into the prone position, while the operator dissects up the integuments of the dorsum until the joint-line is reached and the styloid processes are cleared. The left fingers are used to assist in this retraction.

The surgeon once more grasps the pronated hand, and flexing the wrist to the utmost, divides the left lateral ligament (*i.e.*, the ligament on the operator's left).

By continuing the incision transversely, all the extensor tendons are severed opposite the line of the articulation, the joint is opened, and finally the right lateral ligament is cut.

Still flexing the wrist, and so rotating the hand that the border on the surgeon's right is turned well forward, the operator cuts the anterior ligaments close to the carpus, and clears the bony eminences at the root of the palm. Unless care be taken, the pisiform bone is very apt to be left behind.

Little now is left but the mass of the flexor tendons. These are dragged upon while the wrist is still forcibly flexed, and the knife having been passed between the carpus and the tendons in question, the limb is finally severed by cutting vigorously from within outwards.

In the final cut the palmar incision is of course followed. The wound is united so as to form a transverse cicatrix.

Hæmorrhage.—The radial artery is divided in the dorsal wound at its outer extremity.

At the inner angle of the dorsal wound the carpal branch of the ulnar may be found bleeding.

In the palmar wound are divided the superficial and deep portions of the ulnar artery on the inner side and the superficialis volæ on the outer.

2. **The Elliptical Method.**—So far as the covering of the bones is concerned, this method is nearly equivalent to disarticulation by a palmar flap.

The position of the patient and the operator are the same. The blade of the knife should be four inches in length.

The highest point of the ellipse is on the dorsum, a little to the inner side of the middle line, and half an inch below the line of the wrist-joint.

The lowest point is on the palm, in a line with the middle finger, and about two inches below the level of the highest point.

In forming the ellipse between these two points the incision on the ulnar side should pass between the pisiform bone and the base of the fifth metacarpal, while on the radial side it should cross the carpo-metacarpal joint of the thumb (Fig. 86, B).

Fig. 86.—A, Palmar incision in the circular disarticulation at the wrist; B B, incisions in the elliptical disarticulation at the wrist.

The surgeon, holding the subject's hand in the supine position, marks out the palmar part of the ellipse, commencing the incision on the left side (the surgeon's left) of the hand.

The operator now pronates the hand and marks out the dorsal segment of the ellipse, the assistant at the same time drawing up the integuments at the back of the hand.

The first incision concerns the skin and the subcutaneous tissues only.

The remaining steps of the operation are nearly identical with those of the circular method.

The integuments on the dorsum are separated up until the styloid processes and the joint-line are cleared.

The surgeon, holding the pronated hand in the position of forced flexion, now divides in order the left lateral ligament, the extensor tendons and posterior ligament, and the right lateral ligament. The tendons are divided immediately opposite to the articulation. which is thus freely opened.

The anterior ligament is now severed close to the carpus.

The hand, still hanging down in the position of pronation and flexion, is so rotated that one or other border is turned forwards so as to face the surgeon. While in this position the lateral parts of the ellipse are deepened towards the palm, and the two bony eminences at the root of the palm are cleared, the knife being kept close to the bone.

The instrument is held vertically, with its point downwards, and is passed between the mass of the flexor tendons and the hollow of the carpus. With the knife held in this position the "carpal canal" is cleared out.

Nothing now remains but to divide the flexor tendons and the surrounding soft parts. The tendons are dragged upon and are cut obliquely from within outwards, the knife —now held horizontally—finally following the existing cutaneous incision.

When the wound is adjusted, the cicatrix appears as a curved line upon the dorsum.

Hæmorrhage.—The radial artery is cut in disarticulating, and is found divided at the outer extremity of the dorsal wound. It is severed above the origin of the branches to the thumb and index finger.

In the inner portion of the palmar flap the ulnar artery is divided as it is forming the commencement of the superficial palmar arch.

Deeper in this part of the palmar flap the deep branch of the ulnar artery is cut.

In the outer segment of the palmar flap the superficialis volæ will be found severed.

The deep palmar arch and the greater part of the superficial arch are of course removed with the hand.

3. **By a Long Palmar Flap.**—The flap is U-shaped. It commences half an inch below the radial styloid process, and ends half an inch below the tip of the corresponding process of the ulna. The outer limb is directed towards the gap between the index and middle fingers, the inner limb towards the web between the little and ring fingers.

The almost transverse extremity of the flap reaches nearly to the middle of the metacarpus. Its general outline is

shown in Fig. 87. The dorsal incision is carried straight across the back of the limb from one extremity of the palmar flap to the other. It will therefore cross the carpus.

A stout knife with a blade some three inches in length is required.

The operator grasps the patient's hand and holds it in the position of extension and supination.

Entering the knife half an inch below the styloid process to his left, he carries it across the palm, in the direction indicated, to the corresponding point on the other side of the hand, and thus marks out the palmar flap.

Fig. 87.—DISARTICULATION AT THE WRIST BY LONG PALMAR FLAP.

An assistant now takes the hand and retains it in the same position while the operator proceeds to dissect up the great flap. This should include all the soft parts down to the flexor tendons. A considerable portion of the muscles of the thenar and hypothenar eminences will consequently form a part of the flap, and the limb of the superficial palmar arch will be divided at its free end.

The flap should be dissected up to the level of the radio-carpal joint, care being taken to clear the bony prominences in the palm of the hand.

The surgeon now takes the hand and holds it in the pronated position, while the assistant draws up the skin on the back of the limb. The dorsal incision is made. The integuments are dissected up to the joint-line, and the extensor tendons and the ligaments of the wrist are divided precisely as in the previous operation.

Nothing now connects the disarticulated hand with the

forearm but the mass of the flexor tendons and the tissues about them.

These are drawn upon and divided by a vigorous transverse cut made from above downwards—*i.e.*, from dorsum to palm—care being taken that the palmar flap is held well out of the way at the time.

The palmar flap should never be cut by transfixion. The bony prominences in the palm render such a method difficult, and an unduly scanty flap is apt to result.

Hæmorrhage.—The vessels are divided as in the previous operation. The deep palmar arch and the transverse part of the superficial arch are removed with the hand.

4. **Dubrueil's Operation by an External Flap.** — This ingenious method is thus described by Chalot (*Chirurgie Opératoire,* 1886), who states that he has seen excellent results from this operation in the hands of Professor Dubrueil :—

"The incision is commenced on the back of the wrist at the junction of the outer with the middle third, and at a point half a centimètre below the line of the wrist-joint. It is thence carried downwards towards the thumb upon the dorsal aspect of the limb, and is made to cross the first metacarpal bone transversely about its middle. The incision now follows the inner part of the thenar eminence, and terminates at a point diametrically opposite to the point at which it was commenced. This represents the outline of the external or thenar flap (Fig. 83, G).

"This flap is now dissected up to its base, and is made to include as much of the thenar mass of muscle as is possible.

"The skin and soft parts internal to the flap are then divided in a circular manner through an incision on a level with the base of the flap.

"Disarticulation having been effected, the operation is complete.

"The thenar flap is brought transversely across the face of the radius and ulna, and is there secured."

Comment.—Disarticulation may also be effected by a *long dorsal flap.* This flap has its base at the styloid processes and its extremity opposite the centre of the metacarpus. The method has little or nothing to recommend it. The flap is composed only of skin and tendons, is very retractile, and

very poorly supplied with blood. It affords a scanty covering for the bones, and either the teguments or the underlying tendons are very apt to slough. If the flap be composed of skin only, its fate is nearly certain.

The amputation by *equal palmar and dorsal flaps* corresponds to the circular method, with the addition of a lateral incision extending downwards from each styloid process.

The value of disarticulation at the wrist has been much discussed, and by some surgeons it is advised that in the place of this operation an amputation should be performed through the lower end of the forearm. The objections urged against the disarticulation are the following:—1. The mortality is high. 2. The cartilage, if left on the radius, is apt to necrose. 3. The resulting stump is ill-adapted for the adjustment of an artificial hand.

1. The high mortality appears notably in the records of army surgeons. Fletcher, dealing with the statistics of recent European campaigns, gives the mortality after amputation at the wrist as 42 per cent., while after amputation of the forearm it is 21 per cent. Legouest places the mortality of the wrist amputation at 46·7 per cent.

These figures are only to be explained by the peculiar circumstances of military surgery and the probable frequency of secondary amputations. In civil practice it is rendered evident that the mortality after disarticulation of the wrist is probably about 12 per cent., and that it is decidedly lower than the mortality after amputation of the forearm.

2. If the cartilage be sound, and the wound be treated antiseptically, there is no fear of exfoliation.

3. This assertion does not hold good at the present day. The stump after a successful disarticulation at the wrist is better adapted for the adjustment of a useful artificial hand than is the stump low down in the forearm.

In disarticulation the movements of pronation and supination are usually retained. In forearm amputations those movements are lost.

In the matter of the *technique of the operation* attention may be drawn to the following points:—

The disarticulation is always more readily effected from the dorsum. In dissecting up the palmar tissues, it is not

easy to avoid removing the pisiform bone with the soft parts. It will often be found more convenient to include it in the tissues of the palmar flap, and to subsequently remove it by dissection.

In planning any operation, account must be taken of the very great retractibility of the dorsal tissues, and of the difficulty of properly covering the radial styloid process.

The lower ends of the radius and ulna should not be sawn off. If this be done, the cancellous tissue of the bone is exposed, the pronation and supination movements will be lost, and the attachment of an important flexor—the supinator longus—is disturbed.

Of the operations described, the best procedure is undoubtedly the *elliptical method*. The cicatrix falls upon the dorsum, the bones are well covered, and the free end of the stump is made up of the tough and well-nourished tissues of the palm. The styloid processes are well protected.

The operation by a *palmar flap* may rank next in order of value. It has these disadvantages when compared with the elliptical operation:—The tissues of the palm are more extensively encroached upon; the flap is of a somewhat awkward shape, and, as it includes the tougher parts of the palmar integuments, it is a little unyielding and stiff, and not so readily adjusted as is the smaller and less rigid flap of the elliptical method. The flap, moreover, contains more fatty tissue, and healing after the operation is usually a little slow —a circumstance to which the occasionally horny condition of the skin may no doubt contribute.

In the palmar flap operation the incisions are carried comparatively high up upon the sides of the limb, and there is a little more disposition for the styloid processes to be exposed when the flap is adjusted.

The *circular operation* has the merit of being readily performed. It affords, however, a somewhat scanty covering to the bones, and the cicatrix is placed at the extremity of the stump and over the prominences of bone.

If the tissues of the palm or of the dorsum have been thickened by inflammation, there may be some difficulty in dissecting up the covering of soft parts.

Dubrueil's operation is ingenious, and is said to yield

excellent results. A good covering is provided for the bones, and especially for the radial styloid process. The flap is substantial, and is well nourished with blood-vessels.

The operation is well adapted for cases of injury or disease, where the palmar and dorsal tissues are so damaged as to render any of the three first-named procedures inadmissible.

After-treatment of Disarticulation of the Wrist.—The rigidity and thickness of the palmar tissues render it necessary that in the elliptical or palmar flap operation the sutures should be very securely applied, and should not be too early removed. They should take a hold of the entire thickness of the palmar tissues.

In all instances the stump should be placed upon a short and light palmar splint. In the case of the two operations just named the splint serves to support the palmar flap, and in all disarticulations at this joint it serves to prevent pronation and supination movements.

The possibility of the sloughing of tendons, or of an accumulation of pus in the remains of the synovial sacs for the flexor tendons, must be borne in mind.

A drainage-tube should be inserted, and retained for thirty-six or forty-eight hours.

CHAPTER XVI.

Amputation of the Forearm.

A very large number of different operations has been described under this heading, and there is probably no known method of cutting flaps that has not been recommended as especially suitable to amputation of the forearm.

The fact that the limb undergoes a considerable change in its configuration and physical characters between the elbow and the wrist has no doubt excused the multiplicity of methods.

In the account which follows, two operations will be described, the first being that which appears best adapted for the lower third of the limb, the second one well suited for the upper two-thirds.

Anatomical Points.—At its upper half, and especially in its upper third, the limb is much wider in its transverse than in its antero-posterior diameter. A horizontal section through this part will show a cut surface which is somewhat oval in outline, and is at the same time flattened in front and more convex behind. This outline is best seen in muscular subjects, and depends chiefly upon the development of the lateral masses of muscle which descend from the condyles.

In the non-muscular, the limb, even in its highest parts, tends to assume a rounded rather than an oval outline.

The ulna is subcutaneous throughout its entire extent. The upper half of the radius is deeply placed, while the lower half is superficial.

Transverse sections of the limb at various levels show that the radius and ulna are in all parts nearer to the posterior than the anterior aspect of the extremity. This relation is the more marked the higher up the section. The two bones are nearest to the centre of the limb about the lower end of the middle third.

In antero-posterior flaps cut by transfixion, the anterior flap will consequently be always the more substantial.

At the upper part of the forearm the muscles are found mainly at the sides and in front. The lower the section proceeds down the limb, the less will the bones be covered at the sides, and the more equally will the soft parts be found distributed along the anterior and posterior aspects of the limb. Thus it follows that the circular method is best adapted for the lower third of the fore-arm, and the flap method for the upper two-thirds. It will be obvious also that if antero-posterior flaps be cut of equal width, the bones will have a greater disposition to protrude in the lateral incisions, in the lower part of the limb than in the upper.

It will be noticed that where one bone is the most substantial the other is the most slender, as near the elbow and wrist; and that it is about the centre of the limb that the two are most nearly of equal strength.

The interosseous space is narrowest in full pronation and widest in supination. It is only in the mid-position that the bones are parallel to one another.

There is a singular absence of large blood-vessels and nerves along the posterior aspect of the forearm.

The three chief pronator muscles are the pronator teres, pronator quadratus, and flexor carpi radialis.

The three chief supinators are the supinator longus, supinator brevis, and the biceps. If, therefore, the bones—in an amputation—be divided above the insertion of the pronator teres, the radius will become supinated, and further rotation movements will be lost.

The brachial artery divides opposite to the neck of the radius, and the ulnar gives off the interosseous trunk one inch below this point.

Instruments.—An amputating-knife, with a blade four to five inches in length. A stout scalpel. An amputating-saw. Retractors (the linen retractor used to protect the soft parts during the sawing of the bones may have three "tails," the middle and narrowest slip being passed through the interosseous space). Pressure, artery, and dissecting forceps. Scissors, needles, etc.

Position.—The arm is abducted, and the surgeon stands to the right of the limb in all cases—*i.e.*, to the outer side of the right forearm and the inner side of the left.

One assistant—to the operator's left—steadies the upper arm and retracts the flaps, etc. The other—to the operator's right—manipulates the forearm and hand, and attends to the sponging, etc.

The following *operations* are described :—

1. Circular method.
2. Equal anterior and posterior flaps.
3. Methods less frequently employed.

1. The Circular Method (*through the lower third*).—The position of the incision is estimated in the usual way (page 271). The circular cut in the skin will be placed at a distance below the future saw-line, equal to the antero-posterior diameter of the limb at that line.

The patient's limb is held in the supine position.

The surgeon, passing his hand beneath the patient's fore-arm, commences the incision on that border of the limb which is the nearer to him, and uses the heel of the knife for the purpose.

The knife is now drawn from heel to point across first the flexor and then the extensor aspect of the limb, until it reaches the point at which the incision was commenced.

During this manœuvre the operator grasps the forearm above the incision with his left hand.

A cuff of skin is now dissected up, and turned back as shown in Fig. 75, and this retraction of soft parts should be continued until the level of the future saw-line is reached.

Throughout, the limb is kept with the hand supine, but the elbow should be flexed so as to render the forearm vertical while the posterior part of the *manchette* is being dissected up.

The forearm being extended, with the hand supine, the soft parts on the flexor side of the limb are transfixed by the knife, which is so passed transversely across the forearm that its point is made to enter and emerge at the level of the retracted skin. The knife should follow the curve of the bones, so as to take up as much of the tissues on the front of the limb as possible. It is now made to cut its way abruptly

out, so that the muscles and tendons shall be divided transversely a little below the future saw-line.

The soft parts on the extensor side of the limb are transfixed and divided in precisely the same way, the limb being still kept in the same position during the process.

While the flexor tissues are being cut, the hand is kept a little extended; and while the tissues on the extensor side of the limb are being cut, the hand is a little flexed.

The soft parts might be divided—as is usual—by a circular sweep with the knife at the level of the retracted skin; but as the structures to be severed are for the most part tendons, they are much more easily and more cleanly divided by cutting from within outwards, as advised.

With a scalpel any remaining soft parts are now separated from the bones until the saw-line is well exposed, and at this level the interosseous membrane is divided transversely.

The retractor having been applied, the bones are sawn through. In dividing the bones it is convenient to have the hand placed in the mid-position between pronation and supination, and to saw the radius first and then the ulna.

Many operators keep the hand supine, and endeavour to divide the two bones evenly and at the same time.

Hæmorrhage.—On the face of the flexor part of the wound are found divided the radial and ulnar arteries. The former, no longer accompanied by the radial nerve, lies close to the radius and to the inner side of the conspicuous tendon of the supinator longus muscle.

The ulnar artery will be found lying on the flexor profundus digitorum and under cover of the flexor carpi ulnaris. The nerve is to its inner side. Behind the interosseous space, and between the superficial and deep muscles, the posterior interosseous artery may be found bleeding, and in front of that membrane the anterior interosseous and possibly the median.

2. **By Equal Antero-posterior Flaps** (*through the upper two-thirds*).—The base of each flap should be equal to half the circumference of the limb at the level of the saw-line.

The length of each flap should be equivalent also to half the circumference after the usual allowance has been made for retraction. Thus, to take the measurements recommended by

Farabeuf, if the circumference of the limb in pronation be 80 m.m., each flap should, after retraction, measure 40 m.m.; and to allow for such retraction its length, as marked out upon the skin, should be 60 m.m.

The flaps are U-shaped, and the lateral incisions correspond to the lateral margins of the limb. The anterior flap will contain the supinator longus and the flexor muscles. The posterior flap will contain the extensors. In the radial incision the vertical cut will involve the two extensors of the radial side of the carpus. In the lateral ulnar wound the flexor profundus and the flexor carpi ulnaris are found to be marked by the vertical incision.

The hand having been supinated, the anterior flap is marked out by a skin-cut. In the case of the right limb the knife is entered at the commencement of the ulnar incision, is carried down along the ulnar border, and is then made to sweep transversely across the flexor surface of the limb. The knife being withdrawn, its point is entered at the upper end of the radial incision, and is carried down along the radial border of the forearm to meet the first incision. The flap is marked out therefore by two cuts, and the incision is commenced on the side more remote from the surgeon. In the left limb the knife is first entered upon the radial border.

The elbow being now flexed so that the forearm is vertical (the hand being still supine), the posterior flap is marked out in the integuments only.

The skin thus fashioned for the future flaps is allowed to retract.

The forearm is now again held horizontally, with the elbow a little flexed and the hand still supine.

The operator lifts up the tissues on the front of the limb with the fingers of the left hand, and proceeds to transfix.

The knife is entered at the angle of the wound nearest to the surgeon, and is made to follow as accurately as possible the curves of the bones and the interosseous membrane. Its point should just graze the bones as it moves across the limb.

While the assistant extends the hand, the surgeon cuts a muscular flap from within outwards, bringing the knife out sharply just at the level of the retracted skin.

The posterior flap is cut by transfixion in the same way,

the limb being held in the same posture. It is difficult to insinuate the knife behind the ulna, and its movements in that position must be assisted with the left fingers.

While the muscular tissue is being divided the assistant flexes the hand.

The two flaps are now drawn up to the level of the saw-line, and the remaining soft parts are divided at that level to fully clear the bones.

This is effected by what the French surgeons call the "*incision en* 8 *de chiffre*" (Fig. 88). The knife is made to so pass across the front and back of the limb as to follow the outlines of the bones and to well sever the interosseous membrane. The hand is kept supine, and both the anterior and posterior incisions are made from left to right, and both are commenced by the heel of the knife and completed by its point.

Fig. 88.—THE "INCISION EN 8 DE CHIFFRE." The black and white arrows mark the course of the knife.

The threefold retractor having been applied, the bones are sawn in the manner already described.

Some surgeons advise that the median, ulnar, and radial nerves should be resected from the anterior flap.

Hæmorrhage.—The radial artery will run the whole length of the anterior flap, and be cut near its outer border on the inner side of the supinator longus. The radial nerve accompanies it. The ulnar artery will be cut shorter, will be in front of the bone and between the flexor sublimis and flexor profundus digitorum. The anterior interosseous vessels will be divided immediately in front of the interosseous membrane. The posterior interosseous artery will be cut long, and will be found between the superficial and deep muscles.

The more conspicuous nerves form good guides to the divided vessels.

3. **Other Methods.**—1. *By Long Anterior Flap.*—This flap will measure in an adult's forearm some four and a half inches in length. The posterior flap is one half the length of the anterior. They may be cut in the manner just described.

2. *By Long Posterior Flap.*—This consists in the application of Teale's method to the forearm, and has been adopted for amputations above the wrist. In practising the operation, care must be taken to mark out the flaps by measurement before attempting to cut them, as otherwise, from the conical shape of the limb, the long flap will be apt to be made too narrow at its distal extremity.

If the posterior flap be carried below the wrist-joint, its lower part must consist of skin only, as it is scarcely possible to extricate the tendons from the bony grooves behind the radius.

As this flap is large, and is composed only of tendons and of very thin and retractile skin, and inasmuch as it contains no blood-vessels of any magnitude, it is apt to shrink considerably, to slough, and to form in any case a scanty covering for the bones.

The operation has little therefore to recommend it.

3. *By Skin-flaps with Circular Division of Muscles.*—Mr. Jacobson is of opinion ("Operations of Surgery," page 49) that no method, on the whole, answers so well as this.

The posterior skin-flap is about three inches in length, the anterior two inches. The muscles are divided by a circular sweep at the base of the flaps.

Comment.—The circular method certainly is well adapted for the lower third of the limb, and is no doubt the best amputation in that situation. The soft parts here being composed mainly of integument and tendons, sound flaps cannot well be cut.

It has been urged against the circular operation in this place that there is a tendency for the cicatrix to adhere to the bone. If the bones be well covered, and the healing be by first intention, this objection can have little weight. Such adhesion could be avoided, however, by replacing the circular amputation by the method last described, *i.e.*, amputation by unequal antero-posterior skin flaps with a circular division of muscles.

In the upper two-thirds of the limb the circular method is not admissible unless it be in wasted subjects. Under normal conditions, the outline of the limb, the great mass of muscle, and its intimate adhesion to the bones, are objections to this operation.

CHAPTER XVII.

Disarticulation at the Elbow-Joint.

This operation is not frequently performed, and has been condemned by many as an unsound surgical proceeding.

Messrs. Smith and Walsham ("Operative Surgery," 2nd edition, 1876) give no description of the operation, on the ground that "its advantages are very questionable on the living subject."

The amputation—although it has met with little favour in England—has been extensively practised by French surgeons, by whom, moreover, the principal methods have been devised.

It has been urged against the operation that it is more difficult and less safe than an amputation through the lower part of the arm; that the soft parts have to be divided very low down in order to secure a covering for the bones; that many vessels—those forming the anastomotic plexus about the joint—are divided; that the cartilage is apt to exfoliate; and that a stump is left which is ill-adapted for an artificial limb.

Some of these objections are ill-founded, others have disappeared with the advance of surgical progress.

The disarticulation, although not really difficult, is certainly less easy than an amputation through the arm, which is one of the simplest operations of the kind. Before the development of antiseptic surgery the mortality after this disarticulation was terrible. The statistics derived from the records of the Crimean War show the deaths to have been over 50 per cent. On the other hand, the statistics of the American War produce a mortality from the operation of less than 8 per cent.

It is true that to properly protect the bones a considerable covering of soft parts is required. At the same time the flaps

may be cut in so many ways that the methods employed adapt themselves to a great variety of conditions.

Several vessels are divided, but they are small, and, as a rule, not more than three ligatures are required.

The cartilage very rarely exfoliates, provided that it be sound, and that the wound is treated upon antiseptic principles.

The stump is much better adapted for the application of an artificial limb than is that resulting from an amputation of the arm. French surgeons speak very highly of this operation, and are emphatic as to its value.

Anatomical Points.—On the anterior aspect of the elbow are seen three muscular elevations. One, above and in the centre, corresponds to the biceps and its tendon; while of the two below and at the sides, the outer corresponds to the supinator longus and the common extensor mass, and the inner to the pronator teres and the common set of flexor muscles.

The biceps tendon can generally be very distinctly felt. The crease in the skin known as the "fold of the elbow" is convex below, and is placed some little way *above* the line of the articulation. Its lateral terminations correspond to the tips of the two condylar eminences.

The points of these eminences are always distinct. The inner condyle is the more prominent and the less rounded of the two. The humero-radial articulation forms a horizontal line, but the humero-ulnar joint is oblique, the joint-surfaces sloping downwards and inwards. The external condyle is three-quarters of an inch above the articular line, while the point of the inner condyle is more than one inch above that part.

A line drawn through the two condyles is at right angles with the axis of the upper arm, but forms an angle with the axis of the forearm.

The joint-line of the elbow is equivalent only to about two-thirds of the width of the entire line between the points of the two condyles.

Between the olecranon and the inner condyle is the depression which lodges the ulnar nerve and the posterior ulnar recurrent artery.

To the outer side of the olecranon, and just below the external condyle, there is a depression in the skin, in which the head of the radius can be felt and the inter-articular interval made out. The pit corresponds to the hollow between the outer border of the anconeus and the muscular eminence formed by the two radial extensors of the carpus and the supinator longus.

The skin about the elbow-joint is thin. In front it has a most remarkable disposition to retract after division, and this especially applies to the skin over the radial border of the limb. The integument at the back of the joint is loose, has but little tendency to retract, and is well adapted to bear pressure.

The brachial artery bifurcates about a finger's-breadth below the centre of the bend of the elbow.

The details of the plexus of anastomosing arteries about the joint should be borne in mind.

For a hand's-breadth below the olecranon there is almost an entire absence of superficial veins.

Of the ligaments of the elbow-joint the internal is the most substantial, the external ranking next. The anterior and posterior ligaments are both thin.

In disarticulating, it is well to remember that the triceps is attached not only to the summit of the olecranon, but also to its sides, and that the brachialis anticus is inserted into the ulna beyond the coronoid process.

In children under ten the whole of the upper part of the olecranon is cartilaginous.

The lower epiphysis of the humerus joins the shaft at seventeen, with the exception of the part forming the internal condyle, which joins the shaft at eighteen.

Instruments.—An amputating-knife some six to seven inches in length for transfixion operation. A stout knife with a cutting edge of four to five inches, when flaps are cut from without inwards, and for disarticulating. A scalpel; retractors; pressure, artery, and dissecting forceps; scissors, needles, etc.

Position.—The arm is abducted to a right angle. The surgeon—except in an instance below specified—stands to the right of the limb in all cases, *i.e.*, to the outer side of the right elbow and the inner side of the left.

One assistant, standing to the operator's left and near the patient's shoulder, steadies the arm, retracts and supports the flaps, etc. The other, to the surgeon's right, holds and manipulates the hand and forearm.

The following *methods* will be described:—

1. The circular.
2. The elliptical.
3. The large anterior flap.
4. The single external flap.

1. **Circular Method.**—In order to prepare for the unequal retraction of the skin, the incision must be a little oblique.

Over the supinator longus it should be about three inches below the joint-line, and over the posterior border of the ulna one inch and a half below that level (Fig. 89, A).

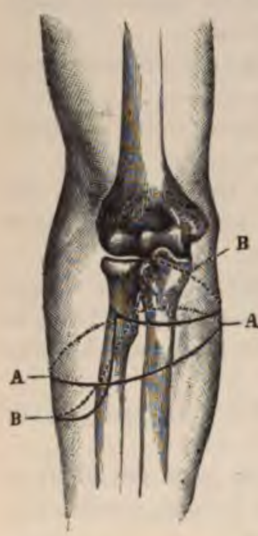

Fig. 89.—A, Disarticulation at the elbow-joint by circular method; B, Disarticulation at the elbow-joint by single external flap.

Grasping the arm with his left hand, while an assistant holds the forearm, the surgeon makes the circular incision with one sweep. He begins with the heel of the knife, and upon the side of the limb nearest to him, and in order to reach that side he passes his own forearm beneath the patient's limb.

The incision involves the skin only, and the integuments are allowed to retract. When retraction has taken place, the skin ceases to appear to have been divided obliquely.

When the integuments have been retracted to a point about one inch below the line of the articulation, the superficial muscles are divided by a circular sweep at that level.

The skin is further retracted until the condyles are reached, and the deeply-placed muscular tissue which is still undivided is cut immediately over the joint. An assistant draws up the divided parts.

The surgeon now grasps the forearm with his left hand, and, keeping the elbow fully extended, cuts the anterior

ligament and then the lateral ligaments; or he may directly enter the joint from the outer side by dividing the external ligament. Nothing now connects the limb with the trunk but the posterior ligament and the triceps.

The tendon of that muscle is the last structure severed.

The skin which formerly covered the olecranon now forms a pouch, and an opening for a drainage-tube should be made in the centre of this depression.

The wound is united so as to form a transverse cicatrix.

Hæmorrhage.—The radial and ulnar arteries will be divided just below their point of origin, or the brachial will be severed close to the bifurcation. In front of the outer condyle the superior profunda, lying by the musculo-spiral nerve, may require a ligature, and the same applies to the termination of the inferior profunda behind the internal condyle.

2. **Elliptical Methods.**—This operation may be performed in one of two ways:—

A. *Anterior Ellipse* (*Farabeuf*).—The figure described by the incision is rather lozenge-shaped than elliptical.

The highest point of the ellipse is behind, over the prominence of the olecranon. The lowest point is on the anterior surface of the limb, over the eminence formed by the supinator longus, and at a spot a little above the middle of the forearm (Fig. 90).

In performing this operation the surgeon may conveniently stand to the left of the limb to be removed, *i.e.*, to the inner side of the right forearm and the outer side of the left. The elbow will be on his right hand, the hand on his left.

The elliptical incision may be made in one sweep from olecranon to olecranon.

Holding the wrist in his left hand, and flexing the elbow a little, the surgeon so rotates the limb as to turn the farther side of the forearm towards him. (This will be the radial margin on the right limb, and the ulnar margin on the left.)

He carries the incision downwards from the olecranon to the lower extremity of the ellipse.

As the knife crosses the anterior aspect of the limb, the forearm is kept extended, with the hand supine.

The elbow is once more flexed, and the limb is now so

held as to bring uppermost the border of the forearm nearest to the surgeon.

The knife is carried upwards across the border to terminate at the point of commencement over the olecranon (Fig. 90).

The incision involves the skin only.

An assistant now takes the forearm, while the surgeon separates and retracts the integuments a little all round.

This retraction will shorten the anterior flap about one inch and a half.

The elbow being a little flexed, and the hand supine, the operator pinches up the soft parts on the flexor aspect of the bones with the left hand, and then transfixes the limb transversely. The knife should be entered as near the joint as possible, and should pass close to the anterior surfaces of the radius and ulna.

Fig. 90. — DISARTICULATION AT THE ELBOW-JOINT BY THE ANTERIOR ELLIPSE METHOD.

The muscles are cut obliquely, and an anterior flap is thus formed.

An assistant draws up this flap, and the surgeon, keeping his knife close to the bones and almost flat, cuts upwards until the anterior aspect of the joint is reached.

Nothing now remains but to disarticulate in the manner already described, and to divide the triceps and any tissues which have escaped division along the lateral and posterior aspects of the limb.

A curved cicatrix on the posterior aspect of the limb results.

Hæmorrhage.—In addition to muscular branches divided with the cut muscles, the radial and ulnar arteries will be found severed near the free end of the anterior flap; and on the deep surface of that flap the interosseous artery, and possibly the posterior ulnar recurrent, may require ligature. Bleeding may also occur from the terminations of the superior profunda in front of the external condyle, and of the inferior profunda behind the inner condyle.

B. *Posterior Ellipse* (*Soupart*). — In this operation the

highest point of the ellipse is in front and the lowest point behind. The flap is therefore taken from the posterior aspect of the limb (Fig. 91).

The procedure is thus described by Ashhurst ("Encyclopædia of Surgery," vol. i., page 640), who considers the method to be "upon the whole the best":—

"The arm being semi-flexed, the point of the knife is entered nearly an inch below the internal condyle of the humerus, curved upwards over the front of the forearm nearly to the line of the joint, and downwards again to a point an inch and a half below the external condyle. The arm being then forcibly flexed, the ellipse is completed on the back of the forearm by a curved incision passing nearly three inches below the tip of the olecranon.

Fig. 91.—DISARTICULATION AT THE ELBOW-JOINT BY THE POSTERIOR ELLIPSE METHOD.

"The cuff thus marked off is rapidly dissected upwards as far as necessary, when the muscles of the front of the forearm are cut about half an inch below, and the ulnar nerve as far above the joint, and disarticulation is effected from the outer side

"The brachial artery is divided, and other vessels may be severed as in the circular operation.

"The wound is closed transversely, and leaves a small curved cicatrix in front of the bone."

3. **By Large Anterior Flap.**—The base of the flap should represent more than half the circumference of the limb, and should be **U**-shaped.

The anterior incision should commence three-quarters of an inch below the line of the joint on the inner side, and one inch and a half below that line on the outer side. The extremity of the flap (the curve of the **U**) should reach some three inches below the articulation.

The posterior incision is made to connect directly the extremities of the anterior incision (Fig. 92).

The position of the operator has been already indicated (page 365). The anterior flap should be marked out by

a skin incision, the limb being at the time extended and the hand supine, and the knife should be entered upon the border of the forearm most remote from the surgeon.

The muscular part of the flap is cut by transfixion precisely as in the anterior elliptical method.

The flap is drawn up and the posterior incision made.

The operation is completed as in the disarticulation by the anterior ellipse, and the blood-vessels are divided in the same manner.

Fig. 92.—DISARTICULATION AT THE ELBOW-JOINT BY ANTERIOR FLAP.

Many surgeons cut a short posterior flap about one-half or one-third the length of the anterior flap.

4. **By Single External Flap.**—This operation—said to have been performed by Joubert in 1848—is usually associated with the name of Guérin.

The flap recommended by Guérin is unduly short. The operation as modified by Farabeuf is here described.

The base of the flap should correspond to about one-third of the circumference of the limb. It is U-shaped, and its extremity reaches a point four inches below the line of the articulation.

The incision marking out this flap commences on the front of the limb, one inch and a half below the joint-line and just to the inner side of the supinator longus. It descends vertically along the inner border of that muscle, and sweeping over the radial margin of the forearm, forms in that position the curve or tip of the U.

The cut is now carried obliquely upwards along the posterior aspect of the limb to end at the level of the articulation, and just external to the olecranon (Fig. 89, B).

The inner incision is carried in a circular manner around the ulnar segment of the limb and connects the extremities of the external incision.

The position of the surgeon has been already indicated. The forearm is held extended, with the hand midway between the positions of pronation and supination, and with the radial border uppermost.

The external flap is first marked out by a skin incision. The cut is commenced on the flexor side on the right limb, and on the extensor side on the left, and at first concerns the integument only.

The unequal retraction of the skin causes the anterior extremity of the wound to reach the level of the posterior extremity.

The skin having been freed, the external flap is cut by transfixion, the knife being passed close to the radius.

The internal incision is now made, and after the skin has retracted the soft parts are divided down to the bone by a vigorous transverse cut at the level of the retracted skin.

The outer flap is well drawn up, and disarticulation is effected from the outer side, *i.e.*, by first dividing the external lateral ligament.

Hæmorrhage.—A few muscular branches are divided in the external flap. The brachial artery, just above its bifurcation, is found divided on the face of the internal wound.

Comment.—Several methods of disarticulating at the elbow-joint have been advised or practised in addition to those described. Among these may be mentioned the amputation by lateral flaps, the external being the larger; by antero-posterior flaps, the anterior predominating; and by a racket incision, the *queue* of which is over the olecranon.

In estimating the comparative value of the four methods described, it will be observed that collectively they meet almost every condition of limited or unequal lesion in which the selection of flaps has to be influenced by the position of the damaged parts.

The *elliptical method*—and notably the amputation by the anterior ellipse—is on the whole the best, provided of course that the tissues upon the flexor side of the limb are sound.

Inasmuch as in cases of accident demanding disarticulation the damage to the soft parts is very often upon the posterior aspect of the joint, the operation is of extensive application.

The flap is well supplied with blood, and provides an excellent covering for the bone. Efficient drainage is permitted, and there is no skin-pouch left over the region occupied by the olecranon. The cicatrix is removed from the extremity of the stump. A considerable demand is made

upon the tissues on the front of the limb, and there is an extensive division of muscle substance.

The operation by the *anterior flap* has the main advantages of this method, and also its disadvantages. It provides, however, a less efficient covering for the condyles, and the olecranon pouch is left. It makes, on the other hand, a less demand upon the tissues on the front of the limb.

The amputation by the posterior ellipse provides a covering for the bone composed of skin accustomed to withstand pressure. The flap is, however, somewhat scanty, and of uneven thickness. It is not well supplied with blood, and the conditions of the stump are by no means well adapted for efficient drainage.

The *circular operation* is a little difficult to perform. It involves but a comparatively small sacrifice of parts. The main artery and the muscles are squarely cut, and the whole wound-surface is consequently small. Excellent drainage is afforded. The end of the humerus is, on the other hand, somewhat scantily covered, and the cicatrix occupies the free extremity of the stump.

The disarticulation of the *single external flap* is well suited for cases of unequal and limited destruction of parts, as in some instances of gunshot injury. The flap, while it provides a good covering for the bone, is not well supplied with blood and does not encourage the most efficient drainage. The resulting cicatrices may be found to be inconveniently placed when an artificial forearm and hand are adjusted.

The After-treatment of Disarticulations at the Elbow.— There is nothing noteworthy with regard to the after-treatment of these operation wounds except the following :—

The stump should be kept raised upon a supporting pillow.

As some of the flaps are bulky, and not disposed to fall into place, substantial sutures are required, and these should not be too early removed.

There is usually so considerable a discharge provided by the synovial membrane that the stump should be drained with a tube. The tube in an ordinary case need not be retained for longer than forty-eight hours.

CHAPTER XVIII.

Amputation of the Arm.

The surgical rule that the least possible amount of the limb should be removed by amputation applies conspicuously to the upper arm.

Even the short stump left when the bone is sawn through at the surgical neck is better than that left by disarticulation at the shoulder-joint. The operation not only involves less risk to the patient, but affords a valuable point of attachment for an artificial limb.

This amputation through the surgical neck will be separately considered in the next chapter.

Anatomical Points.—In women, and in those who are fat, the outline of the arm is rounded and fairly regular. It is less regular in the muscular, in whom it may be represented by a cylinder somewhat flattened on either side and unduly prominent in front (biceps muscle).

The outline of the biceps muscle is distinct, and on each side of it is a groove. The inner of the two grooves is by far the more conspicuous. It runs from the bend of the elbow to the axilla, and indicates generally the position of the basilic vein and brachial artery. The outer groove is shallow, and ends above at the insertion of the deltoid muscle. So far as it goes, it marks the position of the cephalic vein.

The insertion of the deltoid can be well made out, and is an important land-mark. It indicates very precisely the middle of the shaft of the humerus, is on the same level with the insertion of the coraco-brachialis muscle, and marks the upper limit of the brachialis anticus.

It corresponds also to the point of entrance of the nutrient artery (which runs towards the elbow), and to the level at which the musculo-spiral nerve and superior profunda artery cross the back of the bone.

The brachial artery in the upper two-thirds of its course lies on the inner aspect of the shaft of the humerus; in the lower third it is placed directly in front of the bone.

The superior profunda arises near the outlet of the axilla, the inferior profunda opposite the centre of the humeral shaft, and the anastomotica magna about two inches above the bend of the elbow.

The frequency with which variations in the brachial artery are met with should be borne in mind.

The skin is thin and smooth, especially on the inner side of the limb. It is upon this aspect of the limb also that it is the most retractile. The skin over the deltoid is to some extent adherent.

Below the middle of the arm the biceps is the only free muscle, the brachialis anticus and triceps being both closely attached.

Above the middle of the arm nearly all the divided muscles —viz., the biceps, the deltoid, the coraco-brachialis, and the long head of the triceps—are more or less free and capable of retraction.

While therefore the circular operation is well adapted for the lower part of the arm, it is ill-suited for the upper segment.

The upper epiphyseal line of the humerus is horizontal, and is placed a little above the surgical neck. The epiphysis joins the shaft at twenty.

Instruments.—An amputating-knife equal in length of blade to one and a half times the width of the limb for transfixion. A knife with a still longer blade for the circular method. A stout knife, some four inches in length, with which skin-flaps may be marked out and muscles separated from the bone. An amputating-saw. Some seven or eight pressure forceps. Artery and dissecting forceps. Scissors, retractors, etc.

Position.—The patient lies upon the back and near to one or other edge of the table, according to the side of the amputation.

The limb is horizontal, and is abducted until it is at right angles to the body.

The surgeon stands to the outer side of the right arm and the inner side of the left.

One assistant holds the hand and forearm and manipulates the limb. A second stands above the surgeon and attends to the retraction of the divided parts. A third assistant commands the main artery.

The following two *methods* will be described. The first-named is considered to apply especially to the lower half of the arm, the second to the middle of the limb:—

1. The circular method.
2. By antero-posterior flaps.

1. The Circular Method (*lower half of the limb*).—Fixing the arm with his left hand, the surgeon makes a circular sweep through the skin. To effect this he passes his hand beneath the limb, and bending his wrist over the patient's arm, he commences his incision with the heel of the knife, upon the surface of the limb nearest to himself (*i.e.*, upon the outer surface of the right arm and the inner surface of the left).

The assistant holding the forearm so rotates the limb as to make the tissues meet the knife.

The cut can be made to extend with one sweep around about three-fourths of the limb. The circle is completed by withdrawing the knife, and having entered it again at the point of commencement, the surgeon now cuts in the opposite direction—*i.e.*, towards himself—and so incises the small tract of skin yet undivided (Fig. 93, A).

The incision involves the skin only, and care must be taken that the knife does not pass deep enough to wound the brachial artery.

The integuments are now separated especially along the lines of the intermuscular septa, and the skin thus freed is well and evenly retracted by the assistant.

No "cuff" of skin should be turned back. In a stout or muscular arm the proceeding is almost impossible unless a lateral incision be made.

When the skin has been sufficiently drawn up, the biceps is divided about a thumb's-breadth below the edge of the retracted skin.

With a circular sweep of the knife the remaining muscular tissue is divided down to the bone, as close as possible to the edge of the divided integument.

The brachial artery in the upper two-thirds of its course lies on the inner aspect of the shaft of the humerus; in the lower third it is placed directly in front of the bone.

The superior profunda arises near the outlet of the axilla, the inferior profunda opposite the centre of the humeral shaft, and the anastomotica magna about two inches above the bend of the elbow.

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Position.—The patient lies upon the back and near to one or other edge of the table, according to the side of the amputation.

The limb is horizontal, and is abducted until it is at right angles to the body.

The surgeon stands to the outer side of the right arm and the inner side of the left.

One assistant holds the hand and forearm and manipulates the limb. A second stands above the surgeon and attends to the retraction of the divided parts. A third assistant commands the main artery.

The following two *methods* will be described. The first-named is considered to apply especially to the lower half of the arm, the second to the middle of the limb:—

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The assistant holding the forearm so rotates the limb as to make the tissues meet the knife.

The cut can be made to extend with one sweep around about three-fourths of the limb. The circle is completed by withdrawing the knife, and having entered it again at the point of commencement, the surgeon now cuts in the opposite direction—*i.e.*, towards himself—and so incises the small tract of skin yet undivided (Fig. 93, A).

The incision involves the skin only, and care must be taken that the knife does not pass deep enough to wound the brachial artery.

The integuments are now separated especially along the lines of the intermuscular septa, and the skin thus freed is well and evenly retracted by the assistant.

No "cuff" of skin should be turned back. In a stout or muscular arm the proceeding is almost impossible unless a lateral incision be made.

When the skin has been sufficiently drawn up, the biceps is divided about a thumb's-breadth below the edge of the retracted skin.

With a circular sweep of the knife the remaining muscular tissue is divided down to the bone, as close as possible to the edge of the divided integument.

This circular cut is made in the same manner as the first incision in the skin.

The assistant still further retracts the divided soft parts, until they appear as a kind of fleshy cone. A second circular incision is now made at the base of this cone, at the level of the now fully retracted integument. The knife is carried down to the humerus.

The bone is now cleared, the periosteum divided, the retractors are applied, and the shaft is sawn through.

Before applying the saw, it is well to see that the musculo-spiral nerve is cleanly severed. It is apt to escape division, as it lies in the bony groove, and to be mangled by the saw.

The sutures are so applied that the cicatrix becomes vertical (antero-posterior), to ensure good drainage.

Owing to the fact that the skin upon the antero-internal aspect of the limb retracts more than does that upon the remaining part of the surface of the arm, it follows that the cicatrix after an ordinary circular amputation is not terminal, but is drawn forwards and inwards.

To secure a terminal cicatrix, the circular incision should be not quite horizontal, but should incline lower down upon the antero-internal aspect, as shown in Fig. 93, A.

Hæmorrhage.—The vessels are divided upon the face of the stump—the brachial to the inner side with the median nerve; the superior profunda upon the postero-external aspect of the bone with the musculo-spiral nerve; the inferior profunda to the inner side of the brachial with the ulnar nerve. In addition to these three vessels several muscular branches will need to be secured.

2. **By Antero-posterior Flaps** (*middle of the limb*).—The base of each flap should be equal to one-half the circumference of the limb.

The length of the anterior flap should equal that of the diameter of the limb. The posterior flap should be half the length of the anterior.

Both are U-shaped, and the incisions defining them are commenced just below the future saw-line (Fig. 93, B).

These incisions are so disposed that the brachial artery comes in the posterior flap, and great care must be taken that

the division between the flaps is not just over the vessel, which would in such case probably be split in cutting the flaps by transfixion.

An assistant, grasping the limb by the elbow and wrist, flexes the forearm and rotates the extremity as required.

In marking out the anterior flap the arm is so rotated that the flexed forearm is carried towards the surgeon. The incision is commenced on the side of the arm farthest from the operator (*i.e.*, on the ulnar side of the right arm and the radial side of the left).

The knife is carried from above downwards. As it sweeps across the front of the limb to form the tip or bend of the U the arm is held straight, and as the blade is carried upwards to complete the other limb of the U, the arm is so rotated that the forearm is carried away from the surgeon.

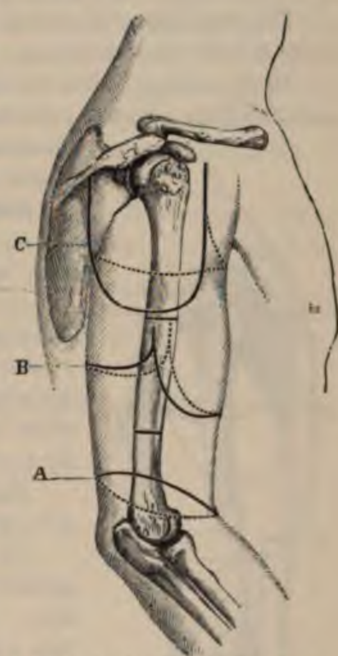

Fig. 93.—A, Circular (inclined) amputation of the arm; B, Amputation of the arm by antero-posterior flaps; C, Amputation at the shoulder-joint by deltoid flap.

The posterior flap is marked out with the knife in the same way, the arm being lifted up so that the surgeon can see the posterior surface.

These incisions concern the skin only.

The skin having been evenly freed all round, the anterior and posterior flaps are cut by transfixion, the edge of the knife being brought out at the level of the retracted skin.

As already said, care must be taken not to transfix nor to slit the brachial artery.

The bone having been freed up to the saw-line, and the flaps well drawn up, the humerus is divided, care being taken of the musculo-spiral nerve. (*See* page 376.)

The objections which have been urged (page 302) against the cutting of the whole flap (muscles and skin) by transfixion, apply with especial force to this part.

The flaps so cut are cut without precision, and the muscles and skin are divided at the same level.

The rapidity with which the operation may be performed is its sole recommendation.

Hæmorrhage.—Some muscular arteries are divided in the anterior flap. In the posterior flap the brachial, the superior profunda, and the inferior profunda are found severed.

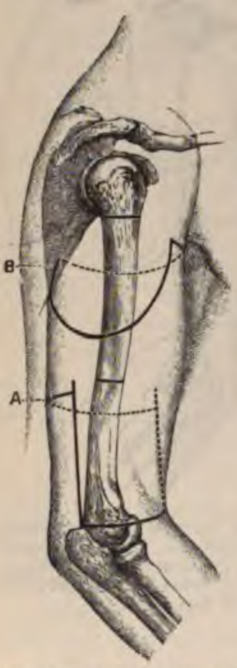

Fig. 94.—A, Amputation of the arm by Teale's method; B, Amputation through the surgical neck by single external flap.

Other Methods.—Among the many other methods of amputating the arm may be mentioned—

(*a*) *Amputation by Lateral Flaps* (Vermale's operation). As the inner flap retracts the more, it is cut the longer; the flaps are marked out by skin incisions and the soft parts are then cut by transfixion.

There is nothing to recommend this procedure.

(*b*) *Teale's Amputation* has been performed in the lower part of the arm. The long flap is placed upon the antero-external aspect of the limb, so that the brachial artery, with the median and ulnar nerves, are found divided in the posterior flap (Fig. 94, A). The operation would be of use in some cases of limited injury.

(*c*) *Malgaigne's Operation* consists in cutting a single rounded flap, usually from the flexor surface—a proceeding "ne durant par une minute."

(*d*) The method known as "*Amputation by Antero-posterior Flaps with Circular Division of Muscle,*" is merely a modification of the circular method. It is little more than the turning back of a divided skin "cuff." The flaps are about 3 to $3\frac{1}{2}$ inches long, and the cutting of them renders

easy the retraction of the integuments—the least simple part of the usual circular operation.

The operation is well suited for very bulky or very muscular limbs.

Comment.—The circular operation is peculiarly well adapted for the lower half of the arm, and is undoubtedly the best procedure for amputation in that situation. The method is not applicable to the upper half of the limb, owing to the freedom of the muscles and their consequent ready retraction. It is here, therefore, that the flap operation proves so serviceable.

A terminal cicatrix would appear to be the one most likely to be free from pressure when an artificial limb has been adjusted.

After the antero-posterior flap operation, the superior retraction of the anterior flap tissues tends in time to make the cicatrix terminal.

The after-treatment of these operations calls for no especial comment.

CHAPTER XIX.

AMPUTATION THROUGH THE SURGICAL NECK OF THE HUMERUS.

IN this operation—the *amputation intradeltoidienne* of the French—the bone is sawn through between the tuberosities of the humerus and the insertions of the pectoralis major and latissimus dorsi.

The muscles left attached to the bone in the stump are the subscapularis, the supraspinatus, infraspinatus, and teres minor.

The saw-cut is a little way below the epiphyseal line. It is difficult to avoid opening the tubular prolongation of the synovial membrane of the joint which accompanies the biceps tendon in its groove.

The bursa beneath the subscapularis tendon commonly communicates with the joint, and may be wounded in operating carelessly.

The posterior circumflex artery and the circumflex nerve wind round the surgical neck of the humerus.

The *advantages* claimed for the operation are these:—

(*a*) The mortality is said to be less than that attending disarticulation at the shoulder.

(*b*) The resulting stump is of considerable value in attaching an artificial limb, and the scapular muscles do not waste to the same degree as occurs after amputation at the joint.

(*c*) The roundness of the shoulder is to a considerable extent preserved.

The *disadvantages* are the following:—

(*a*) There is much risk of opening the shoulder-joint through the synovial diverticula.

(*b*) In young subjects the epiphysis is apt to produce bone after the operation, and to cause a conical stump.

(I once performed this operation upon a lad of twelve, and had on two subsequent occasions to remove portions of the shaft of the bone, to rid the patient of a conical stump produced by an active growth of the epiphysis. The stump, however, as it appeared when the lad reached the age of eighteen years, was admirable.)

(*c*) The stump may be rigidly abducted by the muscles attached to the great tuberosity, and become painful and inconvenient.

The operation may be advised in subjects over sixteen, where the case is uncomplicated and there is every prospect of obtaining speedy healing without suppuration.

One of two methods may be selected:—

1. **Guthrie's Operation by the Oval Method.**—The following is Guthrie's description ("Commentaries," 5th ed., 1853, page 120):—"Amputation of the arm immediately below the tuberosities of the humerus ought to be done in the following manner:—The arm being raised from the side, and an assistant having compressed, or being ready to compress, the subclavian artery, the surgeon commences his incision one or two fingers'-breadth beneath the acromion process, and carries it to the inside of the arm, below the edge of the pectoral muscle, then under the arm to the outside, where it is to be met by another incision begun at the same spot as the first, below the acromion process.

"The integuments thus divided are to be retracted, and the muscular parts cut through, until the bone is cleared as high as the tuberosities. The artery will be seen at the under part, and should be pulled out by a tenaculum or forceps, and secured as soon as divided. The bone is best sawn, the surgeon standing on the outside. The nerves should be cut short, and the flaps brought together by sutures.

"There are few or no other vessels to tie, and the cure is completed in the usual time, whilst the rotundity of the shoulder is preserved."

2. **By Single External Flap.**—This operation is thus described by Farabeuf:—

The surgeon marks out a **U**-shaped flap, the width of which is equal to one-half the circumference of the limb, while its length is not less than that of the diameter of the extremity.

The base of the flap should be two fingers'-breadth below the future saw-line (Fig. 94, B).

The internal incision is slightly curved downwards.

The incisions at first involve the skin only.

When the integuments have retracted evenly, the external flap is cut by transfixion. The tissues composing it are picked up with the left hand as the knife is passed across the base of the flap as near the surgical neck as possible.

The structures on the inner side of the limb, including the axillary vessels and nerves, are now divided one by one, with the following precautions:—

Especial care should be taken to preserve the tendon of the great pectoral muscle.

When the bone is exposed, the periosteum is divided below the bicipital groove, and is carefully stripped up along that groove by means of an elevator, taking with it the greater part of the insertion of the pectoralis major.

The synovial sheath of the biceps tendon should not be opened, and that tendon, having been picked up with the finger, should be divided moderately low down. The coraco-brachialis is divided with it.

The axillary vessels should be cautiously exposed, and the artery and vein ligatured before they are cut.

The nerve cords must be severed high up after they have been individually isolated.

The tendons of the latissimus dorsi and teres major are divided close to the bone, although portions of their attached fibres are separated with the periosteum.

CHAPTER XX.

Disarticulation at the Shoulder-Joint.

Anatomical Points.—The roundness and prominence of the point of the shoulder depend upon the development of the deltoid and the position of the upper end of the humerus. The part of the humerus felt beneath the deltoid is not the head, but the tuberosities—the greater tuberosity externally, the lesser in front.

A considerable portion of the articular head of the bone can be felt by the fingers placed high up in the axilla when the arm is abducted.

The head of the humerus faces very much in the direction of the internal condyle.

The groove between the pectoralis major and deltoid muscles is usually to be made out. In it run the cephalic vein and a large branch of the acromio-thoracic artery. Near the groove and a little below the clavicle the coracoid process may be felt. The process, however, does not actually present in the interval between the two muscles, but is covered by the innermost fibres of the deltoid.

The position of the coraco-acromial ligament may be defined, and a knife thrust through the middle of it would strike the biceps tendon and open the shoulder-joint.

When the arm hangs at the side with the hand supine, the bicipital groove looks directly forward.

In this posture the head of the bone lies entirely to the outer side of a line drawn vertically downwards from the coracoid process.

The skin over the deltoid is comparatively thick and adherent, and retracts little when divided. The skin over the pectoral muscle and over the inner surface of the arm near the axilla is finer, and retracts considerably when severed.

The muscles about the shoulder-joint and their precise attachments should be borne in mind.

The capsule of the shoulder-joint is very lax. Its superior part is best exposed by carrying the elbow across the chest; rotation of the arm outwards brings the anterior part of the capsule to the front, and rotation inwards the posterior part.

The great subacromial bursa intervenes between the capsule and the acromion process.

The main blood supply of the deltoid muscle is derived from the posterior circumflex artery.

This artery, with the circumflex nerve, crosses the humerus in a horizontal line which is about a finger's-breadth above the centre of the vertical axis of the deltoid muscle.

The dorsalis scapulæ artery crosses the axillary border of the scapula at a point corresponding to the centre of the vertical axis of the deltoid muscle.

The acromio-thoracic artery emerges at the upper border of the pectoralis minor, *i.e.*, at a spot where a line drawn from the third rib (near its cartilage) to the coracoid process crosses the line of the axillary artery.

Air may be drawn into the axillary vein or into some of its larger tributaries if they are wounded and happen to be exposed to the atmosphere—as after sponging—during an inspiration.

Methods of Controlling Hæmorrhage during the Operation.—1. The method of controlling bleeding by means of an elastic band, which is carried across the axilla and brought well up over the point of the shoulder, is strongly to be condemned as useless and dangerous. In such a method the axillary artery is compressed mainly against the humerus. At the moment of the disarticulation, the band is apt to slip. It is in the way of the operator, and cannot with any ingenuity be made trustworthy.

2. The compression of the subclavian artery in the neck against the first rib is a more certain mode of controlling bleeding.

The vessel is compressed with the fingers or with an instrument shaped like the handle of a door-key. In stout and muscular subjects, and in cases where the clavicle is lifted up, this method is not applicable. Under such circumstances

some surgeons have advised that an incision should be made over the third part of the subclavian, and the finger or a compressor be introduced through the wound in order that the artery might be more directly reached.

Except under special circumstances, compression of the subclavian is not to be advised. Even with a skilled and careful assistant the method is not absolutely trustworthy. The fingers are apt to slip during the movements of the limb or of the patient, and the assistant who controls the artery is somewhat in the way.

The methods that are the most valuable are the two next described.

3. The main artery may be compressed in the flap by the fingers of an assistant, who takes hold of the part immediately before the vessel is divided.

This procedure is described in the account of Spence's operation (page 388).

4. The artery may be exposed and ligatured before it is divided and early in the course of the operation. An account of this method is given in the description of Larrey's disarticulation (page 390).

Methods of Operating.—Sédillot enumerates twenty different methods of disarticulating at the shoulder-joint, and Lisfranc refers to no less than thirty-six procedures under this head.

Farabeuf gives illustrations of thirty different amputations at the shoulder. These illustrations form an excellent historical atlas, of which the author modestly says, "Il n'est pas complet, quoique plus que suffisant."

Many of these operations have been long abandoned, and are merely curious. Among such may be placed amputations by an axillary flap, as practised by the elder Ledran in 1715, and later by Petit and Garengeot.

Others are merely modifications of well-recognised operations, as illustrated by the various forms of external flap and of antero-posterior flaps.

The majority may be classified as modifications of the oval or racket operations.

It is desirable in any disarticulation performed at the shoulder that the acromion process should be left, since it helps

to preserve some roundness to the shoulder and to afford a point of support for an artificial limb.

It is important also that the axillary vessels be so approached as to be cleanly and certainly cut, and that it be possible to secure them before they are divided.

The glenoid fossa should have as good a covering as is possible, and the methods most frequently practised are those in which the preservation of the whole or greater part of the deltoid muscle is a conspicuous feature.

The wound should be vertical if efficient drainage is to be secured.

It is well that the axillary nerves should be divided high up.

The following *modes of disarticulating at the shoulder* will be described :—

1. The racket method.
    A. Spence's operation.
    B. Larrey's operation.
2. The external or deltoid flap.
3. Other methods.

Instruments.—A stout knife with a blade from four to five inches in length. (If a transfixion operation be performed, an amputating-knife with a blade equal in length to one diameter and a half of the limb will be required.) A scalpel. Ten pressure forceps. Artery and dissecting forceps. An aneurysm needle, metal retractors, scissors, etc.

Position.—The patient lies close to the edge of the table, with the shoulders raised and the head turned to the opposite side. The upper limb is carried a little from the side.

The surgeon should stand to the outer side of the limb in the case of both the right and the left arms. It is often, however, more convenient to stand to the inner side of the left extremity.

Three assistants are required. One stands above the operator, by the patient's head, and, leaning over the shoulder, retracts the flaps and compresses the axillary vessels before they are divided.

A second assistant, standing below the surgeon, by the patient's hip, holds the limb and manipulates it as required.

The third attends to the sponging. He is placed either facing the surgeon and upon the other side of the table, or by the shoulder.

1. **The Racket Method.**—(A) *Spence's Operation.*—The following is Prof. Spence's own account ("Lectures on Surgery," vol. ii., page 662):—

"(1) Supposing the right arm to be the subject of amputation. The arm being slightly abducted, and the head of the humerus rotated outwards if possible, with a broad strong bistoury I begin by cutting down upon the head of the humerus, immediately external to the coracoid process, and carry the incision down, through the clavicular fibres of the deltoid and pectoralis major, till I reach the humeral attachment of the latter muscle, which I divide.

"I then, with a gentle curve, carry the incision across and fairly through the lower fibres of the deltoid towards the posterior border of the axilla, unless the textures be much torn. (The incision so far is carried the whole length directly down to the bone.)

"I next mark out the line of the lower part of the inner section by carrying an incision through the skin and fat only, from the point where my straight incision terminated (*i.e.*, at the lower end of the insertion of the pectoralis major), across the inside of the arm, to meet the incision at the outer part (Fig. 95). This ensures accuracy in the line of union, but is not essential.

Fig. 95.—DISARTICULATION AT THE SHOULDER BY RACKET INCISION. (*Spence's operation.*)

"(2) If the fibres of the deltoid have been thoroughly divided in the line of incision, the flap so marked out can be easily separated (by the point of the finger, without further use of the knife) from the bone and joint, together with the trunk of the posterior circumflex, which enters its deep surface, and be drawn upwards and backwards so as to expose the head and tuberosities.

"(3) The tendinous insertions of the capsular muscles, the long head of the biceps and the capsule, are next divided by cutting directly on the tuberosities and head of the bone

(the humerus being rotated by the assistant as required). The broad subscapular tendon especially, being very fully exposed by the incision, can be much more easily and completely divided than in the double-flap method. By keeping the large outer flap out of the way by a broad copper spatula or the finger of an assistant, and taking care to keep the edge of the knife close to the bone, as in excision, the trunk of the posterior circumflex is protected.

"Disarticulation is then accomplished, and the limb removed by dividing the remaining soft parts on the axillary aspect."

(4) This final step of the operation is effected as follows:—

The arm, abducted and rotated out, is thrust upwards by an assistant until the head of the bone is projecting well above the glenoid cavity. The surgeon, taking hold of the head thus made prominent, draws it away from the trunk, while he passes his knife behind it so as to cut the posterior part of the capsule and the only remaining tissues—those of the axilla—which connect the arm to the trunk.

An assistant follows the knife with his two thumbs, while he keeps the fingers of both hands spread out over the axillary integument. Just before the main vessels are divided he firmly compresses them, and holds the flap until the several trunks are secured.

All the soft parts of the axillary aspect are divided with one sweep of the knife, which is made to emerge from the skin wound already marked out. The operation is completed by cutting the axillary nerves short, and by uniting the wound so as to form a vertical cicatrix.

Spence pointed out that the main vessel might be secured by ligature early in the operation, if thought well. "By a few touches of the bistoury," he writes, "the vessel can be exposed, and can then be tied and divided between two ligatures, so as to allow it to retract before dividing the other textures."

In disarticulating, the capsule should be divided transversely by a cut made upon the head of the bone. The three muscles attached to the greater tuberosity are cut while the humerus is being rotated in, the subscapularis while it is being rotated out.

If the humerus be fractured, the upper fragments should be grasped with lion forceps as soon as the deltoid flap has been dissected up, and manipulated as required during the disarticulation.

When the limb is very muscular, Spence advised that the skin and fat should be raised a little from the deltoid along the outer part of the incision, and that when a certain amount of the lower portion of the muscle had been exposed its fibres should be divided by a second incision. This deep incision would be a good deal higher than the one usually made, and so an excess of muscular tissue in the flap would be avoided.

Hæmorrhage.—The main artery is divided between the origins of the posterior circumflex artery and the superior profunda.

On the edges of the vertical incision there may be bleeding from the humeral branch of the acromio-thoracic artery, and in the depths of that incision the anterior circumflex artery will be divided.

There will be bleeding from muscular branches in the deltoid flap, and considerable hæmorrhage should the posterior circumflex artery be unintentionally cut.

(B) *Larrey's Operation.*—This is the method designated by Farabeuf as the best of the many operations for disarticulation at the shoulder.

The skin incisions are those given by Larrey, the mode of dividing the muscles is ascribed to Marcellin Duval, and the method of securing the main artery to Verneuil.

(1) The limb being held a short distance away from the side by an assistant, the surgeon steadies the skin of the shoulder with the left hand while he makes a vertical cut, which is commenced just below and just in front of the prominence of the acromion, and is continued down the arm for four inches.

Along this incision the knife is carried through the fibres of the deltoid muscle to the bone. By means of this preliminary wound the shoulder-joint may be explored.

(2) From the *centre* of the vertical incision the oval part of the racket is commenced, and is carried across the front of the arm to pass transversely over the inner side of the limb

on a level with the lowest point of the vertical incision. It is finally continued up along the postero-external aspect of the limb to end where it commenced (Fig. 96).

This oval cut at first involves the integuments only. On the right arm it may be made with one sweep of the knife, commencing with the anterior segment of the oval and finishing with the posterior.

On the left extremity the two curved incisions marking out the oval may be commenced at the lowest point, and be each made by cutting from below upwards.

(3) The anterior part of the wound is now deepened by cutting through the anterior segment of the deltoid. The tendon of the great pectoral muscle is exposed, isolated, and divided close to the bone. The coraco-brachialis and biceps are in the next place isolated and then divided.

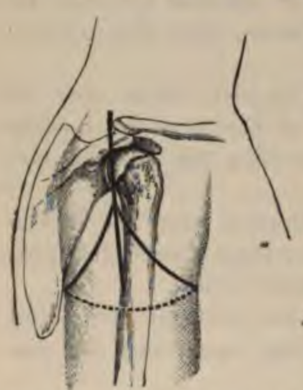

Fig. 96.—DISARTICULATION AT THE SHOULDER-JOINT. (*Larrey's operation.*)

To the inner side of these structures the axillary artery is exposed, and is secured below the origin of the posterior circumflex. It may be secured between two ligatures and then divided.

(4) The operator now turns to the posterior part of the oval, and divides the whole of the posterior segment of the deltoid, carrying the knife back to the under part of the axilla.

While these deep incisions are being made the arm is rotated as required.

(5) Disarticulation is now effected precisely as in the previous operation, and the remaining axillary tissues which connect the limb with the trunk are severed in the same manner.

In this last step of the operation care should be taken that the knife cuts its way out along the skin-wound already marked upon the surface, and that the main vessel is severed only between the ligatures.

Any hanging portions of capsule are removed, the nerves are cut short, and the wound is adjusted vertically.

Hæmorrhage.—The main artery is divided as in the previous operation. Some bleeding may occur from the anterior circumflex artery in the region of the bicipital groove.

The posterior circumflex artery is very apt to be divided in the posterior segment of the oval incision.

2. **The External** or **Deltoid Flap**.—This method appears to have been extensively performed in England prior to the introduction of the disarticulation through the racket incision.

If the outer flap be cut by transfixion, the procedure has the merit of being very rapidly performed.

The operation is one of the two methods of amputating at the shoulder-joint ascribed to Dupuytren. It is associated also with the names of Paroisse (1800), Grosbois (1803), and Charles Bell (1808).

The base of the flap extends from the coracoid process in front to the spine of the scapula at the root of the acromion behind. It is U-shaped, and its extremity reaches nearly to the insertion of the muscle. If well shaped, the flap includes practically the whole of the deltoid. At its base it should be represented by the entire thickness of the muscle, while at its margins it should be comparatively thin.

The surgeon should always stand at the outer side of the limb, and almost facing the patient.

(1) The flap is marked out by a skin-incision. In dealing with the right shoulder, the arm should be carried well across the chest and the knife be entered at the root of the acromion. It is then made to follow the outline of the deltoid, and to end at the coracoid process (Fig. 93, C).

As the knife is carried up towards the latter point the arm is withdrawn from the chest and a little abducted.

It is more convenient that the surgeon should manipulate the limb himself with his left hand.

On the left shoulder the process is reversed. The arm is drawn away from the side and the incision commences at the coracoid. As it approaches the acromion the arm is brought across the chest.

(2) The knife is now carried deeply along the whole length of the incision, and the flap containing the substance of the deltoid muscle is raised. In cutting the flap the knife

should be held a little obliquely, in order that the section of the muscle may be comparatively thin at the margins of the flap.

The flap is drawn well upwards by an assistant, and the outer surface of the shoulder-joint is thereby exposed.

(3) A transverse incision, involving the skin only, is now made across the inner side of the arm, about two inches below the outlet of the axilla. It joins the great wound in front and behind.

(4) Disarticulation is finally effected in the manner already described, and the operation is completed precisely as in Spence's method. That is to say, that after the disarticulation the head of the bone is thrust upwards and outwards, and is grasped by the surgeon, who passes his knife behind it so as to cut the very short internal flap. In effecting this the knife at first passes downward close to the bone, and divides the pectoralis major, latissimus dorsi and teres major muscles. It is then made to cut its way sharply outwards through the incision already made in the skin.

In this, the last movement of the knife, are divided the coraco-brachialis, biceps, and triceps, with the axillary vessels and nerves.

An assistant follows the knife with his thumbs, and compresses the great vessels, before they are cut, in the manner already detailed.

Hæmorrhage.—In the deltoid flap there will be bleeding from muscular branches only, notably from such as are furnished by the acromio-thoracic artery. The posterior circumflex artery will have been cut. The axillary vessels are divided at the free edge of the inner flap, the artery being cut below the origin of the two circumflex vessels. These arteries will be found severed in the margin of the inner flap, and the posterior of the two will certainly require a ligature.

3. **Other Methods.**—The following will be described :—

A. By antero-posterior flaps.
B. By the circular method.
C. By the elliptical method.

A. The amputation by *Anterior and Posterior Flaps* is usually ascribed to Lisfranc.

It was strongly advocated by Fergusson, who practised it

Although the operation would probably not be performed at the present day, it is worthy of note as a brilliant and difficult procedure.

It requires—more than does any other disarticulation at this joint—great skill of hand, and certainty and rapidity of movement.

The description which follows is in Fergusson's own words, and applies to the left limb:—

"The surgeon, standing on the patient's left side, should

Fig. 97.—AMPUTATION AT THE SHOULDER-JOINT BY TRANSFIXION. (From Fergusson's "Practical Surgery," enlarged, but drawn precisely to scale.)

then lay hold of the arm a little above the elbow, and move it from the side and slightly backwards, so as to give a view of the skin in the axilla. An amputating-knife—seven or eight inches in length—held in the right hand, should then be pushed through the skin in the armpit, immediately in front of the tendons of the latissimus dorsi and teres major muscles, and carried upwards and obliquely forwards until its point protrudes a little in front of the extremity of the acromion (Fig. 97).

"During this movement a good anatomist, with a dextrous hand, may actually open the capsule behind, by adroitly

touching the tendons of the teres minor and infraspinatus. . . . . The thrust will be greatly facilitated by moving the elbow outwards, upwards and backwards; indeed, unless this be attended to, there is every chance of the point of the knife appearing through the skin long before it has reached the extremity of the acromion. Keeping the arm in the attitude last mentioned, the knife should be thrust up to its heel, and then carried, with a sawing motion, downwards, backwards and outwards, so as to make a flap four or five inches in length, formed chiefly of the posterior part of the deltoid with the tendons of the latissimus dorsi and teres major and the skin.

"This flap being raised by an assistant, the point of the knife should be used to open completely the posterior and upper part of the joint by a thorough division of the teres minor, infraspinatus, supraspinatus, capsule, and long heads of the biceps and triceps. To facilitate these steps the elbow should now be carried in front of the chest and the head of the bone pushed backwards.

"When the textures are sufficiently divided, the same movement will cause the luxation of the articular surface. The knife should then be passed in front of the bone and carried downwards and forwards, to form a flap about the same length as the other, by dividing the subscapular muscle, the remaining portions of the capsule and of the deltoid, short head of the biceps, pectoralis major, vessels, nerves and skin of the axilla and fore-part of the shoulder.

"In the last movements of the knife the axillary artery must be divided; and to restrain hæmorrhage, an assistant at this period of the operation should grasp the soft parts in the axilla."

On the right limb the process is reversed, and the knife having been entered at the base of the acromion, is brought out at the posterior margin of the axilla.

This operation has little to recommend it except rapidity of execution. The flap is not so good as that formed out of the deltoid alone, a very wide section of the muscles is made, and the procedure has no advantages which can counterbalance the difficulty attending its performance.

B. The *Circular Method*, as advised by Alanson, Cornuau, and others, has never been favourably received. Disarticulation

is almost impossible unless a vertical incision be made to meet the circular cut, and when that has been done the operation is simply an inconvenient modification of the racket amputation.

c. The *Elliptical Method* was employed by Marcellin Duval. The lower point of the ellipse was on the inner side, and was on the level of a point four inches below the acromion. The outer or upper point of the ellipse was two and a half inches below that process.

The operation is clumsy and most difficult, and the flaps are ill-fitting.

Comment.—Of the three chief operations especially described at the commencement of this chapter, the best are those of the racket incision; and of the two detailed, the greater value must attach to Spence's method.

The advantages claimed for the operation are the following:—

1. The articulation is easily exposed, and an excision can be performed through the vertical cut should the case on examination prove to be unsuited for disarticulation.
2. The least possible division of the muscles is made.
3. Disarticulation is easily effected.
4. The posterior circumflex artery is not divided.
5. The main vessels are easily secured.
6. A very excellent stump results.

In Larrey's operation the parts can be divided as neatly and as certainly as in the method just named, and in any case in which Spence's measure may not be applicable this disarticulation may be carried out.

A preliminary examination of the joint can be made, and an excision effected if necessary, but the articulation is exposed at some depth, and a considerable section of the muscular tissues is made. Moreover, the posterior circumflex artery is apt to be cut. A most admirable stump results.

The disarticulation by the external flap is simple and easy, and can be carried out with rapidity.

It does not lend itself, however, to a preliminary exploration of the joint. The circumflex artery is divided and the flap is apt to be ill-nourished. The resulting stump is not a good one. The flap is ill-fitting, and the soft parts do not mould themselves to the glenoid cavity and scapula.

In all these operations it may be claimed that excellent drainage is provided for.

The After-treatment of these Operations.—A drainage-tube will be required, as a considerable amount of fluid commonly escapes from the synovial membrane which is left behind.

Pressure should be applied to the outer flap after the stitches have been introduced, in order that the great cavity left beneath the acromion may be, as far as possible, obliterated.

The method advised by Farabeuf for the adjustment of the wound after Larrey's operation is very excellent.

The median part of the wound is united by sutures as usual. The lower extremity is left open, to permit of efficient and simple drainage. The upper portion of the wound is not united by sutures, but the edges of the incision are brought together by a compress. This compress, which is applied on the outer aspect, not only supports the wound, but also forces the integuments under the acromion, and obliterates the hollow about the glenoid fossa.

The patient's thorax should be kept raised, and the body inclined a little towards the injured side.

CHAPTER XXI.

AMPUTATION OF THE UPPER LIMB TOGETHER WITH THE SCAPULA.

THIS operation, the *amputation interscapulo-thoracique* of French surgeons, has been carried out with considerable success in some few cases of extensive injury of the upper extremity, including gunshot wounds, and in a larger number of examples of malignant tumour, involving the region of the axilla and shoulder-joint, the complete removal of which could not be effected without the sacrifice both of the arm and of the scapula. It has been performed also in examples of extensive bone-disease.

A very elaborate account of the operation was published by Paul Berger in 1887, and the monograph includes the histories of fifty-one cases. The operation appears to have been first performed in 1808 by Ralph Cumming, a surgeon in the British Navy. Mr. Chavasse has appended to an account of a successful operation a list of 44 cases in which the amputation was performed for neoplasmata; out of the 44 cases 10 may be counted as cured (*Med.-Chir. Trans.*, vol. lxxiii., 1890). The mortality in the non-traumatic cases has been 20 per cent., and in the traumatic cases 30¾ per cent. The chief risks of the operation are from shock, hæmorrhage, the entrance of air into veins, and from purulent infection.

The amputation involves the removal of the upper limb, together with the scapula and the outer two-thirds of the clavicle. No disarticulation is attempted at the shoulder-joint.

Method.—The best method is that of Paul Berger by two flaps—an antero-inferior or pectoro-axillary flap, and a posterior-superior or cervico-scapular flap.

The Steps of the Operation.—The amputation may be divided into four stages.

1st. The clavicle is exposed and is divided at the junction of the middle with the inner third. The middle third of the bone is excised. The subclavian vessels are exposed, and are secured by double ligatures and divided.

2nd. The antero-inferior flap is fashioned and the brachial plexus severed.

3rd. The postero-superior flap is fashioned.

4th. The extremity is removed by dividing the tissues still connecting the scapula with the trunk.

Instruments.—A strong, stout amputating-knife with a blade from five to six inches in length; a stout scalpel; a periosteal elevator curved on the flat; metal retractors, spatulæ, and blunt hooks; a keyhole-saw or a fine chain-saw; bone forceps, lion forceps, aneurysm needle, pressure forceps, artery and dissecting forceps, scissors, etc.

Position.—The position of the surgeon varies with each step of the operation, and is described below. Three assistants should be at his service.

The Operation.—1*st Step.*—The patient lies upon the back, close to the edge of the operating-table. The shoulders are raised upon a hard cushion. The arm is by the side or a little separated from it. The surgeon stands to the outer side of the limb, facing the patient. Two assistants are placed one on each side of the surgeon. A third assistant stands on the other side of the body and facing the operator.

The clavicular incision is now made with a stout scalpel. The incision is horizontal, is made along the surface of the bone, commences internally at the outer border of the sterno-mastoid muscle, and ends externally just beyond the acromio-clavicular articulation.

The knife divides everything down to the bone.

At this stage the sometimes large connecting vein which may pass between the external jugular and cephalic veins may be severed.

The periosteum of the clavicle is divided along the horizontal line corresponding to the original wound, and is also divided vertically or circularly at the inner extremity of the wound.

The inner third of the clavicle is not disturbed in any way.

By means of a small rugine or periosteal elevator curved

on the flat, the periosteum is separated from the superficial part of the middle portion of the bone, which is now well exposed.

During the use of the elevator an assistant should steady the collar-bone, and render it as prominent as possible.

A large, blunt hook may now be very carefully passed round the inner end of the exposed clavicle, and while an assistant draws the bone forward and steadies it by means of this hook the surgeon saws it through at about the junction of the middle with the inner third. The section is accomplished by means of a keyhole-saw, or by a fine chain-saw, the former being the more convenient.

The blunt hook serves to guide the saw and in some way to protect the deeper parts. During the sawing the middle of the clavicle should be grasped and further fixed by means of lion forceps. The bone is the more conveniently divided (with the hand-saw) if the blade be directed downwards, outwards and backwards. A perfectly straight vertical section of the bone is difficult and unnecessary.

The outer fragment of the divided clavicle is now drawn forwards by the lion forceps, the remaining periosteum is separated from its posterior and deep surfaces, and the bared bone is then again sawn through at the outer end of the middle third.

The middle third of the clavicle is thus entirely removed. The exposed subclavius muscle is now isolated, is divided close to the site of the inner section of the bone, and is dissected up so as to expose the great vessels, and turned outwards.

Fasciæ of varying thickness will have to be divided before the vessels are reached.

A double ligature is passed round both the artery and the vein, and between the ligatures each vessel is divided.

The ligature takes place at the lower border of the first rib and the artery should be exposed and secured before the vein, in order that as little blood as possible may be left in the extremity.

2nd Step.—While the patient is still lying on the back, the body is brought as near to the couch as possible, and the shoulder is made to project beyond it.

1st. The clavicle is exposed and is divided at the junction of the middle with the inner third. The middle third of the bone is excised. The subclavian vessels are exposed, and are secured by double ligatures and divided.

2nd. The antero-inferior flap is fashioned and the brachial plexus severed.

3rd. The postero-superior flap is fashioned.

4th. The extremity is removed by dividing the tissues still connecting the scapula with the trunk.

Instruments.—A strong, stout amputating-knife with a blade from five to six inches in length; a stout scalpel; a periosteal elevator curved on the flat; metal retractors, spatulæ, and blunt hooks; a keyhole-saw or a fine chain-saw; bone forceps, lion forceps, aneurysm needle, pressure forceps, artery and dissecting forceps, scissors, etc.

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The outer fragment of the divided clavicle is now drawn forwards by the lion forceps, the remaining periosteum is separated from its posterior and deep surfaces, and the bared bone is then again sawn through at the outer end of the middle third.

The middle third of the clavicle is thus entirely removed. The exposed subclavius muscle is now isolated, is divided close to the site of the inner section of the bone, and is dissected up so as to expose the great vessels, and turned outwards.

Fasciæ of varying thickness will have to be divided before the vessels are reached.

A double ligature is passed round both the artery and the vein, and between the ligatures each vessel is divided.

The ligature takes place at the lower border of the first rib and the artery should be exposed and secured before the vein, in order that as little blood as possible may be left in the extremity.

2nd Step.—While the patient is still lying on the back, the body is brought as near to the couch as possible, and the shoulder is made to project beyond it.

An assistant draws the upper limb away from the body, and the surgeon stands to the inner side of the limb, *i.e.*, between it and the trunk. The whole of the scapular region should be free of the table, the back resting upon the hard cushion, which is at the very edge of the table, and the head being drawn to the opposite side.

The assistant moves the limb as required during the cutting of the pectoro-axillary flap.

Fig. 98.—INTERSCAPULO-THORACIC AMPUTATION.

The incision marking out this flap is commenced at the centre of the clavicular incision, is then curved downwards and outwards, passing just beyond (*i.e.*, to the outside of) the coracoid process, and then runs along the deltoid muscle, parallel to, but to the outer side of, the groove between that muscle and the pectoralis major (Fig. 98). On reaching the point where the anterior wall of the axilla joins the arm, the incision crosses the lower margin of the pectoralis major, and passing transversely across the skin upon the inner or axillary surface of the arm, reaches the lower margin of the tendons of the latissimus dorsi and teres major. At this point the limb is well raised by the assistant, and the wound is completed by carrying the knife downwards and inwards to stop over the posterior surface of the inferior angle of the scapula. In the last part of the course the knife follows the groove between the

vertebral border of the scapula and the muscular mass formed by the teres major and latissimus dorsi.

The incision involves at first only the skin and the subcutaneous tissues.

The surgeon now dissects up the structures of the flap which comprise the soft parts of the pectoral and axillary regions.

The pectoralis major is divided about where it is becoming tendinous, the pectoralis minor is severed close to the coracoid process. An assistant holds back the tissues of the flap, while the surgeon exposes the cords of the brachial plexus, which are then divided at the same level as the main vessels, *i.e.*, close to the first rib.

The shoulder now falls outwards away from the trunk, and the axilla is fully opened up. Any undivided connections of the limb in the axillary region are freed.

The latissimus dorsi is severed in the line of the incision, and serves to form part of the flap.

3rd Step.—The patient lies still in the same position at the extreme edge of the table; but the arm is now carried across the chest by an assistant so as to well expose the scapular region, and the surgeon takes his place to the outer side of the extremity.

He proceeds to cut the postero-superior flap.

The incision starts at the outer termination of the first or clavicular incision (*i.e.*, at a point just beyond the acromio-clavicular joint), and is carried backwards by the shortest route over the scapular spine to meet the termination of the anterior flap incision, at the inferior angle of the scapula (Fig. 98). The wound concerns the integuments only. The skin is well reflected in the upper part of the incision, so as to lay bare the trapezius muscle. This muscle is divided close to its attachments to the clavicle and scapula, and is entirely severed from its connections with the limb.

4th Step.—Nothing now remains but to sever the connections of the scapula with the trunk.

One assistant holds back the anterior flap, another the posterior. The limb is allowed to hang away from the side, supported by a third assistant, and steadied and directed by the left hand of the operator.

The operator himself may conveniently stand to the inner

side of the right arm and the outer side of the left. The superior and vertebral borders of the scapula being made prominent, the following muscles are rapidly divided from above downwards close to the bone: the omo-hyoid, levator anguli scapulæ, rhomboideus minor and major, and the serratus magnus.

The limb is now free. The two teres muscles, the subscapularis, and the supra- and infra-spinatus muscles go untouched with the amputated extremity.

Hæmorrhage.—The early ligature of the main vessel renders the bleeding in this formidable operation comparatively slight. In resecting the clavicle and exposing the great vessels no noteworthy bleeding is encountered. In fashioning the anterior flap hæmorrhage may be expected from several muscular arteries and from branches of the acromio-thoracic and long thoracic. The subscapular artery should not be disturbed, although its thoracic branch will be divided.

In fashioning the posterior flap no vessels of any note will be encountered except muscular branches in the trapezius muscle, which are divided as the muscle is cut.

It is during the fourth step of the operation that most hæmorrhage is to be expected. It will come from the vessels descending from the neck or from the supra-scapular and the posterior scapular. The former—a small artery the size of the lingual—may be secured close to the omo-hyoid muscle, and as it is about to pass into the supraspinous fossa. The posterior scapular, a somewhat larger vessel, reaches the superior angle of the scapula by following the levator anguli scapulæ muscle. The vessel may be cut and clamped immediately after division of the muscle.

After-treatment.—The wound, when closed with sutures, forms an oblique line running from above downwards, outwards and backwards. A large pocket is left in the stump, in which inflammatory exudations may readily collect. This pocket should be obliterated by pressure, a matter best accomplished by packing the wound with sponges, over which the pressure of a bandage is brought.

If this be well effected, and if no diseased or damaged tissue have been left behind, a drainage-tube is not required. The patient should be kept well raised up in bed.

CHAPTER XXII.

AMPUTATION OF THE TOES.

As in the majority of cases amputation of the toes is performed for injury, it is not always possible to carry out the precise lines of a formal operation. In not a few instances the "amputation" consists merely in removing a little bone and in trimming a mangled stump.

Anatomical Points.—The two outer toes—and possibly the third toe—are commonly found to be much bent upon themselves, and not lying straight as shown in surgical diagrams. This bending consists in a flexing of the last phalanx or of the last two phalanges upon the first.

The joints of the toes should be defined. The middle of the length of each toe about corresponds to the joint between the first and second phalanges. The line of the metatarso-phalangeal joints follows an easy curve, and is about one inch behind the web of the toes. The head of the first metatarsal bone and the line of its joint can be readily made out by a little manipulation. The heads of the first and of the third metatarsals are in the same transverse line. The head of the second is about 3 m.m. in front of this line, and the head of the fourth about 3 m.m. behind it; while the head of the fifth metatarsal is a little more than 1 c.m. (nearly half an inch) behind the line.

The last phalanges of the four outer toes are small, squat bones, often nearly square, and an amputation "through" the last phalanges of these toes would in many instances be an absurdity. The shafts of the first and second phalanges are slender and compact, and can be easily divided with bone forceps. (*See* page 306.)

Each phalanx has one epiphysis at its proximal extremity It is represented by the base of the bone, and joins the shaft between the nineteenth and twenty-first years.

The prominent part of each phalangeal joint—each knuckle—is formed by the head of the proximal bone.

The inter-phalangeal and metatarso-phalangeal joints are each supported by two lateral ligaments and a glenoid ligament. The former are nearer to the plantar than the dorsal aspect of the joint. The tough, fibrous, glenoid ligament occupies the whole of the plantar aspect of the joint. The head of the proximal bone rests on it; the lateral ligaments join it; it is more firmly attached to the base of the distal bone than the head of the proximal one. Beneath it glides the flexor tendon, the fibrous sheath of which is fixed to it. In the glenoid ligament of the first metatarso-phalangeal joint two sesamoid bones are developed. They are received in grooves on the head of the metatarsal bone, but their more intimate structural connection is with the phalanx. The fibrous sheaths for the flexor tendons have the same arrangement in the foot as in the hand, and the same care should be taken to effectually close them when divided. (*See* page 322.)

In dealing with the anterior part of the foot it must be remembered that the foot rests upon the heel, the heads of the metatarsal bones, and the inner margin of the sole. In amputation, therefore, every care should be taken to save as much as possible of the metatarsus, and especially of the first metatarsal bone and the phalanges of the great toe. The same care need not be taken to preserve every possible part of the four outer toes. A sloughing stump has often resulted from too great anxiety to preserve these almost useless digits.

Instruments.—Stout, narrow scalpels, with blades from one inch to two inches in length, and with well-rounded points. A fine keyhole-saw, or minute Butcher's saw. Bone forceps. Dissecting and artery forceps. Tapes to retract the toes. Scissors, needles, etc.

Position.—In all these operations upon the toes the patient should lie on the back, and the foot be brought well beyond the end of the couch. The surgeon should sit at the end of the table facing the patient. The assistants stand—facing the surgeon—one on each side of the end of the table. One should fix the limb and hold the toe, while the other attends to the wound.

The operations included in this chapter will be dealt with in the following order:—

A. Amputation of the distal phalanges.
B. Disarticulation at the metatarso-phalangeal joints.
C. Amputation of the toes *en masse* through the metatarsus.

A.—AMPUTATION OR DISARTICULATION OF THE DISTAL PHALANGES OF THE TOES.

1. Disarticulation of the Last Phalanx of the Great Toe. —*Large Plantar Flap.*—Hold the toe between the thumb and first two fingers of the left hand—the thumb on the pulp of the toe, the fingers on the nail. Cut the plantar flap as the toe is thus held. Enter the knife—at right angles to the surface—just over the head of the first phalanx. Cut along the side of the toe to the pulp. This incision should be parallel to the phalanx, and nearer to the dorsal than the plantar aspect. Shape the flap as shown (Fig. 99) and return to the same point on the opposite side. The incision should extend down to the bone.

Fig. 99.—DISARTICULATION OF THE LAST PHALANX OF THE GREAT TOE BY A LARGE PLANTAR FLAP.

Let the assistant forcibly extend * the last phalanx while the flap is dissected back, it being held by the left hand while so doing. In making this flap the surgeon must keep as close as possible to the bone. When the glenoid ligament is reached, cut it transversely against the base of the last phalanx. The joint is thus opened.

Now let the surgeon forcibly flex the toe and make a transverse cut across the dorsum that at once divides the extensor tendon and opens the joint. Rotate the toe out, and carefully divide the internal lateral ligament. Rotate it in and divide the external band, and the disarticulation is

* To avoid confusion of terms this note may be given: Flexion of a toe=the bending of the toe towards the sole—action of the flexor muscles. Flexion of the foot=the bending of the foot at the ankle so that the toes are brought nearer to the shin—action of extensor muscles.

complete. In disarticulating, keep the knife very close to the bone, so as to avoid wounding the plantar digital arteries. Cut the lateral ligaments from without inwards. The cicatrix of the stump will come well on the dorsum.

The long plantar flap should not be cut by transfixion. By so doing the vessels are needlessly damaged and the flap is apt to be scanty. If, on the other hand, too large a flap be cut, a pocket is made for pus.

Hæmorrhage.—The two dorsal digital arteries will be cut at the corners of the dorsal incision. They are small, and usually do not need to be secured. If the flap has been well cut, the two plantar digital arteries will not be wounded, but will lie buried in the flap until they anastomose at its free end. They may readily be cut if in dissecting the flap back the knife is not kept close to the bone. They also lie near to the sides of the joint (plantar aspect) and may be easily wounded in careless disarticulation.

In *amputation through the last phalanx of the great toe* the same operation should be employed, the dorsal incision being made nearer the nail. It should be a rule that no more of the great toe should be removed than is absolutely necessary. An endeavour should be made, when possible, to spare the base of the second phalanx. By so doing the joint is undisturbed, and the insertions of the flexor and extensor tendons are saved.

2. **Amputation** or **Disarticulation of the Distal Phalanges of the Four Outer Toes.**—In operating upon the smaller toes the neighbouring digits should be held aside by the assistant by means of tapes. It is well not to use too long a scalpel.

The terminal phalanges may be removed by the operation just described.

In *disarticulation of the second phalanx* use the oval or racket incision. Grasp the toe with the left hand and flex it. Enter the knife 1 c.m. above the joint and in the median dorsal line. Continue the incision—which should be only skin-deep—along to the middle of the second phalanx. Now curve it down to the plantar margin, cutting to the bone. Forcibly extend the toe and draw the knife transversely across its plantar aspect. Still cut to the bone, and so make a good division of the flexor tendon. Cut up on the opposite

side of the toe to meet the straight dorsal incision (Fig. 100, A). In this step cut also to the bone.

Now let the assistant forcibly extend the toe; dissect up the lateral and plantar parts of the cut; divide the glenoid ligament transversely against the base of the second phalanx and thus open the joint. Then divide the lateral ligaments, and nothing will retain the toe but the extensor tendon. Pull upon the toe and divide this tendon as high up as convenient. Close the sheath of the flexor tendon (page 322). The cicatrix will be vertical, *i.e.*, dorso-plantar.

Fig. 100.—A, Disarticulation of the second phalanx of a toe by the racket or oval incision: B, Disarticulation of the great toe by the racket or oval incision.

Hæmorrhage. — Two dorsal and two plantar digital arteries are found cut in the lateral edges of the wound. The dorsal will require no attention, the latter may be twisted.

In *amputation through the first phalanx* employ the circular method. Make a circular cut round the phalanx at the level of the web; cut to the bone. As the knife crosses the dorsum, flex the toe so as to cut the extensor tendon short. As the scalpel crosses the plantar aspect, extend the digit to its utmost. Separate the soft parts from the phalanx as high up as possible, and divide the bone. Close the sheath of the flexor tendon (page 322). The vessels are cut as in the last instance. The cicatrix should be vertical, *i.e.*, dorso-plantar. Amputation through the first phalanx may also be effected by two lateral flaps of equal size cut by transfixion with a narrow bistoury.

Comment.—The phalanges of the four outer toes are of little use; their absence is usually not unpleasantly felt.

In disarticulating the second phalanx, I should remove the head of the first phalanx, or replace the operation by an amputation through the latter bone at the level of the web. The head of the first phalanx is large, and is apt to play the part of a foreign body between the other toes when it is left. Its removal is no detriment to the use of the foot.

As has been observed elsewhere (page 306), the bone should be divided by a very fine saw rather than crushed by forceps.

For the treatment of the tendon-sheaths in some of these amputations, *see* page 322.

B.—DISARTICULATION AT THE METATARSO-PHALANGEAL JOINTS.

1. Disarticulation of the Great Toe at the Metatarso-Phalangeal Joint.

In this operation notice must be taken of the very large size of the head of the metatarsal bone. Its dimensions are increased by the presence of the sesamoid bones, which should never be removed with the phalanx. It is of considerable importance to the future use of the foot that the head of the metatarsal bone should be preserved, and it will be seen that the chief difficulty of the operation is to provide flap enough to cover the projection. It is important also that the scar should be away from the plantar surface and the line of the sesamoid bones.

Fig. 101.—DISARTICULATION OF THE GREAT TOE BY INTERNAL PLANTAR FLAP.

The joint can be readily made out by manipulation, especially on the inner aspect of the foot. It is placed about an inch behind the web. The projection of the sesamoids can also very easily be defined.

The following are the chief methods of operation:—

(1) *By Internal Plantar Flap* (*Farabeuf*).—The surgeon sits to the front and the inner side of the foot. The four surfaces of the digit—dorsal, plantar, internal, and external—should be noted and conceived to be each of equal extent. The joint-line is made out, and the toe being grasped with the left hand, the knife is entered over that line and at a point where the dorsal and internal surfaces meet. An incision, 2 c.m. in length, is made along the toe, parallel to the extensor tendon and on the line between the two surfaces named. It is then curved downwards over the inner surface to the plantar margin (Fig. 101). The toe is now turned in,

and the knife, placed beneath the member, is drawn across the plantar surface to the edge of the web between the toes. The knife is now held above the toe, and the incision completed by a cut to the point of starting, made by the shortest route. The whole of this incision should involve the skin only.

It should now be deepened down to the bone in the same order. In drawing the knife across the plantar surface, extend the toe, so as to cut the flexor tendon high up. Dissect back the flap, keeping close to the bone. In so doing, the assistant should hold the toe and turn it to one or other side as required, while the surgeon uses his left fingers to turn back the soft parts. Separate the tissues about the point of starting; clear the soft parts from the surface of the joint. Forcibly extend the toe, and cut the glenoid ligament transversely close to the base of the phalanx. The joint is thus opened; the ligament, with the sesamoid bones, remains behind. Divide the lateral ligaments, and finally cut the extensor tendon. Close the fibrous sheath for the flexor tendon (page 322).

Fig. 102.—DISARTICULATION OF THE GREAT TOE BY INTERNAL PLANTAR FLAP: THE RESULTING STUMP. (*Farabeuf.*)

Hæmorrhage.—The outer plantar digital artery will be found cut close to the web, the inner vessel at the free end of the inner flap. The dorsal digital vessels will probably not need to be secured.

The flap is adjusted as shown (Fig. 102).

(2) *By Racket* or *Oval Incision.*—The toe is grasped by the left hand. The knife is entered about 1 c.m. above the metatarso-phalangeal joint in the dorsal median line. It is continued down to the centre of the first phalanx, and when carried round the toe to form the racket should just avoid the web (Fig. 100, B). The proceeding is identical with that described in disarticulation of the second phalanx (page 406). The joint should be opened from below, through the glenoid ligament.

The fibrous sheath for the flexor tendon is closed (page 322).

In disarticulating, the toe should be manipulated by the

assistant, while the surgeon holds back the soft parts with his left fingers. The toe should be turned and twisted to the inner side when dividing the outer lateral ligament, and to the outer side when dividing the inner one. In dissecting back the flap, it is well to keep close to the bone, so as to avoid injury to the digital vessels.

In disarticulating, also, care must be taken to keep close to the phalanx and to cut towards the bone; the soft parts must be well dissected back and the ligaments exposed. If such care be not taken, the plantar digital arteries—which lie close to the joint—will be divided. The cicatrix comes over the head of the bone and is vertical to the sole.

Fig. 103.—DISARTICULATION OF THE GREAT TOE BY INTERNAL FLAP.

The digital arteries will be found divided at the free margin of the flap on either side.

(3) *By Internal Flap.*—The surgeon grasps the toe with the left hand. The incision is commenced on the dorsal aspect, about 2 m.m. below the joint-line and just to the outside of the extensor tendon. It is continued straight down the dorsum of the toe to the level of the interphalangeal joint. From this point a transverse cut is made across the dorsal, internal, and plantar aspects of the toe to the outer border of the flexor tendon (Fig. 103). The incision is now carried back to the web along the outer margin of this tendon. From the web a transverse cut is made across the external and dorsal surfaces to meet the dorsal incision, which it joins about its centre. The whole of this incision should at first involve the skin only.

The internal flap is now dissected up from below upwards. The knife must be kept close to the bone. The extensor tendon is exposed and cut over the joint-line while the toe is being flexed. The joint is thus opened, the lateral ligaments are cut, and a final plantar incision—made while the toe is extended to the utmost—divides the flexor tendon and the glenoid ligament. Close the fibrous sheath of the flexor tendon (page 322.)

The outer digital vessels are cut close to the web, and the inner in the free edge of the inner flap.

The flaps need not be cut quite so square as is shown.

The cicatrix comes well to the outer side, close to the web, and under cover of the second toe.

Comment.—Of these three operations, the first described is undoubtedly the best. The cicatrix is out of the line of pressure and is well protected, while the adjustment of the wound is such that excellent drainage is permitted. In the oval operation the cicatrix comes directly over the head of the bone. Good drainage is, however, permitted, and the operation is very easily carried out. It may claim perhaps to be the most ready of the three procedures.

The disarticulation by internal flap is not so convenient. The flap is not readily made and is a little clumsy; the cicatrix, however, is well placed.

In all these disarticulations great care must be taken not to cut the digital arteries, as is so readily done in clearing the bones. The toe has no other source of blood-supply, and if the vessels are cut it is little wonder that the flaps slough or are slow in healing. The artery should run the full length of the flap.

When possible, the base of the first phalanx of the toe should be saved, on account of the important series of muscles to which it gives attachment (abductor and adductor pollicis, flexor brevis pollicis, and transversus pedis). Although these muscles can no longer act upon the toe, they are of value in maintaining the strength of the sole.

The skin in this region is often much thickened, and is consequently unyielding, and in adjusting flaps care must be taken that too much strain does not come upon the sutures.

2. Disarticulation of the Outer Toes at the Metatarso-Phalangeal Joints.

The best operation is that by the *oval* or *racket incision* already described (pages 329, 409). Care must be taken that the toes on either side of the one to be removed are held apart by tapes by the assistant.

In disarticulating the little toe, the *dorso-external flap* advised by Farabeuf will be certainly found to give the most convenient stump. Its application, however, in practice must be exceedingly limited.

The knife is entered on the dorsum, just below the joint,

and to the inner side of the extensor tendon. The incision follows the inner edge of the tendon for the whole length of the first phalanx. It is then inclined outwards across the outer aspect of the toe, and carried back to the level of the web. By this means a U-shaped flap, with unequal limbs, is formed from the structures on the dorsal and external surfaces. The two extremities of the U are now united by a cut which crosses the plantar and internal aspects of the toe, and joins the dorsal incision by the shortest route.

Fig. 104.—DISARTICULATION OF THE LITTLE TOE BY DORSO-EXTERNAL FLAP: THE RESULTING STUMP. (*Farabeuf.*)

The cicatrix that results from this amputation is removed from pressure. It lies well to the inner side, and is protected by the fourth toe (Fig. 104).

The importance of closing the tendon-sheaths has been discussed on page 322.

3. **Disarticulation of the Toes en masse at the Metatarso-Phalangeal Joints.**

This is best effected by short dorsal and plantar flaps.

The operator should sit at the end of the table, facing the foot, which should project some way beyond the extremity of the table.

The line of the metatarso-phalangeal joints must be defined (page 403).

The chief difficulty in the operation is to provide a sufficient covering for the large head of the first metatarsal bone.

Supposing the left foot to be the one dealt with, the operator grasps the toes with the left hand, his thumb being on the dorsum and his fingers on the plantar surface. The foot is turned out, and the knife is entered just over the metatarso-phalangeal joint of the great toe. The point of entrance should be midway between the plantar and dorsal surfaces. An incision is now made from this point along the inner side of the foot. It is longitudinal, and is carried as far as the centre of the first phalanx.

The foot is now extended and the toes are gently flexed,* while the incision is carried abruptly across the dorsum

* *See* foot-note, page 405.

The cut crosses the centre of the first phalanx of the great toe transversely, and then follows the line of the web.

To follow the hollows between the toes, the operator must separate each pair a little with his left fingers as he proceeds. On reaching the dorsum of the little toe, the incision is carried longitudinally back along the lateral margin of the little toe to the level of the metatarso-phalangeal joint.

This incision may in the first instance involve the skin only. The dorsal flap thus marked out must be dissected back. The assistant takes charge of the toes, which he keeps flexed; the surgeon has his left hand free to manipulate the flap. The flap should contain all the soft parts down to the extensor tendons. When about half the flap has been dissected back these tendons should be divided. Before each one is cut the corresponding toe should be flexed to its utmost by the assistant. The flap is carried back until the line of joints is exposed.

The plantar flap is now cut. The toes are held in the extended posture by the surgeon, his thumb being on the plantar aspect and his fingers on the dorsum.

The incision is simply transverse, and joins the distal ends of the two lateral incisions. It is so carried across the foot as to follow the creases which separate the toes from the sole. The incision should extend to the flexor tendons. The flap is dissected back, the assistant keeping the toes extended. When the flap is about half made, the flexor tendons may be divided, and the whole of the soft parts are then dissected back to the line of joints.

The flaps should be now sufficiently retracted to well expose this line. The articulations having been opened on the dorsal aspect, the lateral ligament of the first joint is divided; the toes are then extended fully, and the line of articulations finally opened from the plantar aspect. The glenoid ligaments are preserved. The disarticulation should then be completed, joint by joint, in the left foot, from the inner to the outer side. In the right foot the incisions are commenced at the outer side, and the disarticulation is begun at the joint of the little toe.

The sheaths of the flexor tendons should be closed.

Hæmorrhage.—The plantar digital arteries will be found

divided some way down on the plantar flap, and the dorsal digital at about the same place on the dorsal flap.

The latter will probably not need to be secured.

Comment.—This is a dead-house operation, and one that can scarcely ever be required in the living subject. It may be called for in some very limited cases of crushed toes, and possibly in some instances of frost-bite.

By some it is advised that the line of articulations be opened by one sweep ("by a sawing movement") after the flaps have been cut. Such a manœuvre would be rapid, but at the same time clumsy, and calculated to damage the flaps and the heads of the bones.

Dubrueil advises a more or less circular incision, and cuts a **U**-shaped flap from the inner side of the great toe in order that the head of the first metatarsal bone may be effectually covered (Fig. 105).

Fig. 105. — DUBRUEIL'S OPERATION FOR THE REMOVAL OF ALL THE TOES.

C.—AMPUTATION OF THE TOES EN MASSE THROUGH THE METATARSUS.

This operation is carried out upon the same principles as that just described.

The best procedure is that of a *long plantar flap*. The foot should project beyond the end of the table, and the surgeon should sit facing it. The points at which the bones are to be sawn must be first determined. The saw-line must be oblique, so as to follow the natural line of the metatarsal bones; *i.e.*, the section of the fifth metatarsal must be posterior to the section of the first metatarsal. The saw-cut, in fact, should be about parallel with the line of the web. The plantar flap may be cut first. This is done with the foot well flexed.*

Assuming the left foot to be the one operated on, the knife is entered at the inner margin of the foot, midway between the dorsal and plantar surfaces. The point of entrance is

* *See* foot-note, page 405.

over the first metatarsal, and is just behind the point at which that bone is to be divided. The incision is carried along the side of the foot until the level of the crease that separates the great toe from the sole is reached. It is now made to sweep across the plantar surface just behind the web. On reaching the outer surface of the little toe, the incision is carried back along the margin of the foot until a point is reached just posterior to the spot selected for the section of the fifth metatarsal bone. In making this plantar incision the surgeon should keep the foot rigid with his left hand, and at first the cut should be through the skin only. An assistant now takes the foot and keeps it well flexed at the ankle, while the surgeon uses his left fingers to aid in dissecting back the flap. The flexor tendons should be divided as soon as the separation of the flap has been well commenced. While they are being cut the individual toes must be fully extended.

The plantar flap should contain all the soft parts down to the bone.

The foot having been extended, the dorsal incision is made. It should be parallel with the plantar cut, and should join the lateral parts of the plantar flap about one inch from their points of commencement. In other words, this little flap is about one inch in length. The flap must include all the soft parts down to the bone. The extensor tendons should be divided when the flap is about half separated.

In dividing the bones, the plantar flap should be carefully protected by an ivory spatula. Each bone should be sawn separately from the dorsal aspect with a fine narrow saw. The rude crushing of the bones with cutting forceps is not to be advised.

It is to be remembered that the shafts of the metatarsal bones are embraced by the interossei muscles. These must be cleanly divided before the saw is applied.

The cicatrix comes upon the dorsum of the foot.

Hæmorrhage.—In the plantar flap six arteries (the digital) may possibly require to be secured. One will be found opposite to each of the four interosseous spaces, a fifth opposite the outer side of the fifth metatarsal, and a sixth opposite the inner side of the first metatarsal. The two latter vessels

may not require to be secured. The largest vessel is that opposite the first interosseous space.

Vessels similarly placed will be divided in the dorsal flap. Probably none will require attention except the artery (the first dorsal interosseous) that is cut opposite the gap between the first and second metatarsal bones.

Comment.—This is a very useful amputation in cases of crush of the toes, and in limited gangrene from frost-bite, etc. If the tissues in the sole are damaged, the dorsal and plantar flaps may be of equal size. A single dorsal flap should be avoided. Pezerat advised three flaps—one from the dorsum, one from the sole, and one from the inner margin of the foot.

THE AFTER-TREATMENT OF AMPUTATIONS OF THE TOES.

It must be confessed that the wounds of these operations do not always heal so kindly as may be expected, and often compare unfavourably with like wounds in the hand. In many cases this is due to the fact that the operation is an imperfect one—a mere trimming of a mangled part—and is the outcome of a desire to remove as little tissue as possible.

The less easy circulation of the part, and the circumstance that the wound is less conveniently placed for drainage, serve to some extent to explain the tardier healing when compared with operation wounds of the fingers.

The limb should be kept out in the open air, for reasons already detailed (page 69). The leg should be a little raised upon a pillow, and the patient should lie so that the foot can rest upon one or other side. When the patient lies flat on the back, the toes point upwards, drainage is rendered almost impossible, and every facility is given for the gravitation of the discharges of the wound into the depths of the foot. If the flaps have been so carelessly cut as to involve some sloughing, if the tendon-sheaths have been left open, if the wound is loosely dressed and exposed to the vitiated atmosphere under the bed-clothes, and if the foot is so placed that proper drainage is impossible, it is no matter for wonder that the stump does not do well, and that deep-seated suppuration is detected in the foot.

All tight bandages should be avoided.

As the skin of plantar flaps is usually thick and stiff, sutures should be so applied as to retain a good hold of the parts. They should not be removed too soon, as the flap may give way. Silkworm-gut sutures may often be left in for ten or even fourteen days.

Portions of divided tendons may slough, and a watch should be kept for signs of inflammation along the lines of those tendons.

The smaller amputations require no drainage-tube. In operations upon the great toe, a fine tube, or a tube split in halves, may be retained for the first twenty-four hours.

CHAPTER XXIII.

Partial Amputation of the Foot.

AMPUTATIONS THROUGH THE TARSO-METATARSAL JOINTS.

These operations consist in the removal of single toes, with their respective metatarsal bones, and in the removal of the whole of the metatarsus by Lisfranc's and Hey's operations.

The amputation of a single toe, together with the whole of its metatarsal bone, is an operation of little practical utility. It may possibly be of service in some very limited and rare forms of disease, and it is conceivable that it may be called for in some exceptional accidents. The occasions, however, must be peculiarly uncommon. The great toe and the little toe are the ones most likely to afford material for this operation. The elaborate procedures described by French authors for the disarticulation of the second or the third or the fourth toe, together with its metatarsal bone, are purely dead-house operations. To the student the performance of these disarticulations is of service as affording a training for the more ready carrying out of Lisfranc's operation.

Anatomical Points.—The following account is derived from Mr. Henry Morris's valuable work on "The Anatomy of the Joints." There may be said to be three separate joints between the tarsus and metatarsus. First, the joint between the internal cuneiform bone and the first metatarsal; second, that between the three cuneiforms and the second and third metatarsals; and third, the joint between the cuboid and the fourth and fifth metatarsal bones. Looked at as a whole, the union of the tarsus with the metatarsus is very uneven, owing to the backward projection of the second, fourth, and fifth bones behind the line of the third, and the forward position of the first, which articulates with the inner cuneiform nearly half an inch in advance of the second, and about a quarter of an inch

in front of the third metatarsal bone, where they articulate with the middle and outer cuneiforms respectively. The second metatarsal is let back into a space between the three cuneiform bones. The three outer metatarsals are placed pretty evenly in a line having a gentle curve, with its convexity towards the phalanges (Fig. 106).

The Inner Tarso-Metatarsal Joint.—The internal cuneiform bone presents a large, nearly flat, kidney-shaped, articular surface, inclined a little inwards. Its long axis is vertical, and measures one inch. Its breadth is half an inch (Fig. 107). The facet on the first metatarsal is of the same general shape. This bone is connected with the inner cuneiform by a complete capsule, the fibres of which are very thick on the under and inner aspects. Those on the outer side pass from behind forwards in the interval between the interosseous ligaments which connect these two bones with the second metatarsal. The plantar ligament is by far the strongest.

Fig. 106.—BONES OF FOOT. A A, Line of Lisfranc's amputation.

The Middle Tarso-Metatarsal Joint.—The facets on the middle and external cuneiforms are flat and triangular, with their bases at the dorsum. Each measures about three-quarters of an inch vertically, and the width of its base is about half an inch (Fig. 107). Lateral facets on the inner and outer cuneiform bones articulate with like facets on the sides of the base of the second metatarsal. The posterior facets on the second and third metatarsals correspond in size and shape with those on the two middle cuneiforms.

The ligaments of the joints are the following:—Dorsal: between the bases of the two metatarsals and the three cuneiform bones. Plantar: a strong ligament between the inner cuneiform and the second and third metatarsals, and slender ligaments between the middle cuneiform and the second metatarsal, and the outer cuneiform and the third bone. Interosseous: the middle portion of the tarso-metatarsal joint is shut off from the inner portion by a very strong

interosseous ligament (the ligament of Lisfranc), which extends between the outer surface of the first cuneiform and the inner surface of the base of the second metatarsal. A second band runs from the external cuneiform to the third and fourth metatarsals, and shuts in the joint on its outer side.

Fig. 107.—TRANSVERSE SECTION OF THE FOOT AT THE TARSO-METATARSAL LINE OF JOINTS.

C, Cuboid; I.C., M.C., E.C., The three cuneiform bones; 1, Ext. prop. pollicis; 2, Ext. long. digit.; 3, Ext. brevis digit.; 4, Peron. tertius; 5, Peron. brevis; 6, Peron. longus; 7, Tibialis ant.; 8, Flex. long. poll.; 9, Flex. long. digit.; 10, Abduct. min. digit.; 11, Flex. brev. digit.; 12, Abduct. hallucis.

The Cubo-metatarsal Joint.—The cuboid looks forwards and outwards, and presents two unequal facets, which articulate with like facets on the fourth and fifth metatarsal bones (Fig. 107). Dorsal and plantar ligaments pass between the cuboid and the two bones, while the interosseous ligament just named shuts off the joint on its inner side.

The *synovial membrane* of the inner articulation is single, and separated from all the other tarso-metatarsal joints. That of the middle articulation is an extension forwards from the synovial membrane of the scapho-cuneiform and outer cuneiform articulations, while the synovial membrane of the cubo-metatarsal joint is special to that articulation and to the joint between the bases of the fourth and fifth metatarsal bones.

Each metatarsal bone has one *epiphysis*, which is placed at the distal extremity of the four outer bones (and forms the head), and at the proximal end of the metatarsal of the great toe, of which it forms the base. The epiphyses join the shafts between eighteen and twenty.

The following *attachments of tendons* may be noted:—To the base of the first metatarsal bone the peroneus longus and part of the tibialis anticus; to the base of the fifth metatarsal the peroneus brevis and peroneus tertius.

The communicating branch of the dorsalis pedis artery passes between the bases of the first and second metatarsal bones. The plantar arch crosses the joint between the fourth

and fifth metatarsals obliquely, and runs over the bases of the second and third metatarsals at some little distance from the line of the tarso-metatarsal joints.

Instruments.—A stout knife with a blade three inches long. (For the flap operation upon the great toe a more slender knife, with a blade of about three and a half inches in length.) Narrow metal retractors. Lion forceps (in the event of the part being crushed). Dissecting, pressure, and artery forceps.

Position.—The same as for previous amputations. (*See* page 404.)

DISARTICULATION OF A TOE, TOGETHER WITH ITS METATARSAL BONE.

Disarticulation of the Great Toe, together with its Metatarsal Bone.—(A) *By Oval* or *Racket Incision.*—Having defined the metatarso-tarsal joint, grasp the toe with the left hand, and enter the knife at the inner border of the foot, just below the line of the joint. Carry the incision outwards, parallel to the articulation line, until the centre of the dorsal aspect of the metatarsal bone is reached (Fig. 117, A). Now continue the cut straight down towards the nail, along the median line of the dorsum of the bone. This incision will lie to the inner side of the extensor proprius pollicis tendon. On reaching the centre of the metatarsal bone, incline the incision to the web, then round the outer side of the root of the toe (the phalanx being turned out), and so on to the plantar aspect. Let the knife cross the plantar surface transversely in the groove that separates the toe from the sole. Finally, curve the incision round the outer aspect of the toe to reach the dorsal wound at the centre of the metatarsal bone. The incision involves the skin only.

Now deepen the dorsal cut. Divide the tendons of the extensor proprius and extensor brevis close to the metatarso-tarsal joint. Separate the soft parts from the inner and outer sides of the bone, keeping close to it, and cutting from the tarsus towards the toe. While effecting this separation the assistant turns the toe to one or other side, and the surgeon uses his left fingers to draw away the soft parts. The assistant now partly extends the toe, and, the flexor tendon having been cut, the

soft parts are dissected off from the plantar aspect of the bone. The bone should be bared back to the joint. The sesamoid bones are left behind.

Care must be taken not to wound the communicating branch of the dorsalis pedis artery which runs between the two toes.

The next step is to open the joint on the dorsal aspect, and as far as possible on the outer and inner sides. The surgeon now once more grasps the toe and divides the plantar and remaining ligaments. Last of all, the tendons of the peroneus longus and tibialis anticus are cut, and the toe with its metatarsal bone is free.

Cut the flexor tendon short, and close its sheath (page 322). If the transverse cut at the commencement of the incision be not employed, the wound must start over the cuneiform bone.

Hæmorrhage.—The dorsal digital branches (of the first interosseous artery) to the sides of the toe are divided in the dorsal incision. The inner one will probably need no attention. In the plantar aspect of the wound are divided the termination of the internal plantar artery, the first plantar digital artery, and the internal digital branch to the great toe. There is great risk of wounding the communicating branch of the dorsalis pedis in the gap between the first and second toes.

(B) *By the Flap Method.*—Having grasped the toe with the left hand, the knife is entered on the dorsum of the foot over the proximal end of the metatarsal bone. The incision is carried forward on the dorsum of the bone until its head is reached. It now crosses the inner side of the toe to the plantar aspect of the foot, and thence is continued back to a spot immediately below the point of commencement.

Both the dorsal and plantar incisions may be made by cutting from behind forwards, and then joined by a vertical incision over the head of the bone. The flap thus marked out is now dissected back. In doing this the surgeon draws back the divided soft parts with his left fingers while the assistant holds the toe. The extensor tendons are left *in situ*. The flap must include everything down to the bone. When it has been dissected back to beyond the level of the joint,

the extensor tendons are divided, and the joint opened on its dorsal and internal aspects. The tendon of the tibialis anticus is divided at this step.

Now, having grasped the toe in the left hand, the surgeon thrusts the knife between the bases of the two metatarsals, keeping the blade very close to the inner bone, and brings the point out at the plantar wound. The knife is then made to cut its way out between the two toes. The soft parts are cleared from the plantar aspect of the bone, the flexor tendon is divided high up, and finally, the ligamentous structures at the outer side of the joint having been divided, together with the peroneus longus, the toe is free. The sesamoid bones are removed with the toe. The flexor sheath should be closed.

Hæmorrhage.—In the outer surface of the wound—the wound left by the transfixion cut between the toes—are divided the dorsal digital branches to both sides of the great toe, the internal digital branch to the same toe, and the first plantar digital artery. The only bleeding point in the flap will belong to the termination of the internal plantar artery.

The first dorsal interosseous artery is very apt to be cut, as is also the communicating branch from the dorsalis pedis. In clearing the soft parts it is most important to keep close to the bone.

Comment.—Of these two operations, the first-named is unquestionably the better. The flap operation involves a large wound and a badly-placed cicatrix. The flap is thin, especially on its dorsal aspect, and is very poorly supplied with blood.

Disarticulation of the Little Toe, together with its Metatarsal Bone, by the Oval or **Racket Incision.**—The toe being grasped by the left hand, the knife is entered at the outer margin of the foot about 1 c.m. behind the tuberosity of the fifth metatarsal bone. An oblique cut—parallel with the cubo-metatarsal joint—is made (Fig. 116, A), and a median dorsal incision is carried thence to the neck of the metatarsal bone. Here the oval is made just as in the disarticulation of the great toe (page 421). The subsequent steps of the operation are practically identical with those already described.

The outer tendon of the extensor longus digitorum lies to the inner side of the wound, and is divided at the highest

point of the dorsal incision. At this point also some portion of the fleshy part of the extensor brevis will be exposed.

When the outer and inner sides of the bone have been cleared of soft parts, the tendons of the peroneus tertius and peroneus brevis are cut, the joint between the cuboid and fifth metatarsal, and also that between the bases of the fourth and fifth bones are opened from the dorsum. The plantar surface of the bone is then cleared, and the disarticulation is completed as in the case of the great toe.

To the base of the bone strong processes from the plantar fascia are attached, and require division. It should be remembered that a double articulation is opened in this operation (page 420).

Hæmorrhage.—In the dorsal incision the dorsal digital arteries of the toe are divided, while the plantar digital vessels are found cut on the plantar aspect of the wound.

Any one of *the other metatarsal bones* may be removed, with its corresponding toe, by the oval incision. The outer two bones may in like manner be removed together by the oval operation, the *queue* of the oval running along the interosseous space between the two bones.

As already stated, these operations are of little practical value. (For the after-treatment, *see* page 442.)

LISFRANC'S OPERATION.

A disarticulation of the anterior part of the foot at the tarso-metatarsal line, useful in limited cases of bone disease, of frost-bite, or of gangrene, and in some examples of perforating ulcer of the foot. (For the anatomy of the line of joints, *see* page 419, and Fig. 106.)

Instruments.—A strong, stout, narrow knife, about four or five inches long in the blade; a scalpel; a saw, in the event of the joints being anchylosed; a narrow metal spatula; pressure forceps, artery and dissecting forceps; lion forceps if the toes be crushed.

Position.—The patient lies on the back. The foot is drawn well beyond the end of the table, and is raised upon a support until on a level with the surgeon's neck. The operator may stand to cut the dorsal flap, but should sit at the end of the table facing the patient, to cut the sole flap

and complete the disarticulation. The assistants stand one on each side of the end of the table.

Operation (*Right Foot*).—1. *The Dorsal Flap.*—Grasp the extended foot with the left hand, so that the thumb is on the base of the fifth metatarsal bone and the forefinger on that of the first, while the palm of the hand faces the sole. The skin on the dorsum is stretched, and the knife is held in the free hand, with the forefinger on the back of the blade. In this position the dorsal flap is cut. The incision commences at the outer margin of the foot, just behind the tubercle of the fifth metatarsal bone (Fig. 108). For about an inch it follows the outer border of the bone. It then sweeps across the dorsum parallel to the line of the tarso-metatarsal joints, and about half an inch in front of it. The cut is curved towards the toes, and reaches the plantar aspect of the inner border of the foot about half an inch in front of the tarsal joint of the great toe. It finally follows the inner margin of the foot, and ends three-fourths of an inch behind the said joint.

The assistant now holds the foot fixed in the extended position while the surgeon uses his left fingers to dissect back the dorsal flap. The dissection at first includes the skin only; but when the integument has been retracted about one-fourth of an inch, the extensor tendons are divided. The flap contains therefore all the soft parts down to the bones. It is important to well expose the metatarsus, and to carry the flap back far enough to expose the tarso-metatarsal joint-line. (*See* the Comment upon the operation, page 428.)

2. *The Plantar Flap.*—The plantar flap is now cut. The surgeon flexes the foot with the left hand, his thumb being along the line of the toes, and his fingers on the dorsum. The knife is introduced at right angles to the surface of the now well-exposed sole. The incision, commencing on the outer side, follows the plantar edge of the fifth metatarsal for a short distance, and then sweeps obliquely across the sole to the neck of the fourth metatarsal. It now traverses the sole just behind the line of the heads of the metatarsus, and finally follows the plantar edge of the metatarsal bone of the great toe to join the extremity of the dorsal incision. The plantar flap is thus convex forwards, and the inner segment is longer than the outer (Figs. 108 and 118, A).

The incision at first involves the skin and the subcutaneous tissues only. The assistant now grasps the toes and keeps them fully extended while the surgeon dissects back the flap. This should include the subcutaneous structures only until the hollow behind the heads of the metatarsal bones is reached. When this hollow is exposed, the tightly-stretched flexor tendons are divided by a vigorous transverse cut. The rest of the flap includes all the soft parts down to the bones. These are dissected up by short transverse cuts with the knife while the operator pulls back the flap. The separation is carried back until the line of the tarso-metatarsal articulations is reached. The exposure of the peroneus longus tendon will indicate when this line is reached. The tendon should for the present be left uncut.

Fig. 108.—LISFRANC'S AMPUTATION.

3. *The Disarticulation.*—Return to the dorsum. Grasp the foot with the left hand and extend it fully. Let an assistant hold back the dorsal flap with one hand while by means of a metal spatula he retracts and protects the plantar flap with the other. Enter the knife just behind the tubercle of the fifth metatarsal bone, and, cutting obliquely forwards and inwards, open the tarsal joints of the three outer metatarsal bones. In this manœuvre the tendons of the peronei brevis and tertius are divided. Now turn to the inner side of the foot, and open the joint between the first metatarsal and the inner cuneiform, cutting at the same time the tibialis anticus expansion. In the next place, open the joint between the second metatarsal and the middle cuneiform on its dorsal aspect. The complete separation of the metatarsal bone is difficult, and is thus effected: Hold the knife like a trocar and—keeping it nearly parallel with the dorsum of the foot—thrust the point in deeply between the bases of the first and second metatarsal bones (Fig. 109) until it is arrested by bone.

The edge is turned towards the ankle. Now grasp the knife in the hand like a dagger, and elevate the handle until it is perpendicular to the dorsum of the foot, at the same time cutting in the direction of the external malleolus (Fig. 110). By this manœuvre (the *coup de maître*) the strong ligament of Lisfranc (page 420) is severed.

Fig. 109.—THE COUP DE MAÎTRE IN LISFRANC'S AMPUTATION: FIRST STEP. (*After Guérin.*)

Divide any remaining ligaments, especially those on the plantar aspect of the joints, and finally the metatarsus is left attached only by means of the peroneus longus tendon. Draw this tendon out, and cut it at the outer angle of the incision and the parts to be removed are free.

Fig. 110.—THE COUP DE MAÎTRE IN LISFRANC'S AMPUTATION: SECOND STEP. (*After Guérin.*)

Left Foot.—Commence the dorsal and plantar incisions on the inner side of the foot. In disarticulating, open first the

joint between the metatarsal bone of the great toe and the inner cuneiform, then open the tarsal joints of the three outer metatarsals, and finally disarticulate the second metatarsal.

Hæmorrhage.—In the dorsal flap are divided the dorsal interosseous arteries (four), opposite to the interosseous spaces, and the plantar branch of the dorsalis pedis as it dips down between the bases of the first two metatarsal bones. In the plantar flap are divided the plantar digital branches of the external plantar, and probably that vessel itself, near the base of the second metatarsal. The terminal part of the internal plantar artery is also divided.

Comment.—The dorsal flap having been made, the disarticulation may be at once proceeded with, and the operation completed by cutting the plantar flap from within outwards—*i.e.,* practically by transfixion. Or the disarticulation having been effected from the dorsum, the plantar flap may be subsequently cut in the manner already described. On the other hand, the operation may be commenced by cutting the plantar flap, and then be completed by the making of the dorsal flap and disarticulation.

These various modifications, together with the procedure described at length, are all known generally by the term "Lisfranc's operation."

The stump resulting from this amputation is well formed and useful.

The following points may be observed in the performance of the operation :—

It is a common fault to make the dorsal flap too small, and to limit it strictly to the dorsum. This flap should include not only the dorsal structures, but also the greater part of those of the outer and inner margins of the foot. The relative sizes of the two flaps may be estimated by noting the measurement of half the circumference of the foot at the amputation-line. An unduly large plantar flap forms an unwieldy pocket. If the dorsal incision be carried too far back, the joint between the scaphoid and cuneiform bones may be opened by mistake on the inner margin of the foot.

In dissecting back the dorsal flap the knife should be kept close to the bones, and care must be taken not to damage the interosseous vessels that run in the flap. In this flap

portions of the interossei muscles will be found, and especially some fibres of the first dorsal interosseous. The line of the articulations must be well exposed.

In disarticulating, care must be taken not to damage the plantar flap. During the separation of the second metatarsal from the tarsus, I have seen the foot so vigorously extended that the bone has been fractured through its base, and much difficulty has been experienced in removing the fragment thus left behind.

HEY'S OPERATION.

This operation resembles Lisfranc's procedure in all essential points, and differs only in this—the four outer metatarsal bones are disarticulated from the tarsus, and the projecting end of the internal cuneiform bone is sawn through, carrying the first metatarsal bone with it. As "Hey's operation" has been variously described, I give here the original description :—

"In the year 1799 I had the opportunity of repeating this operation" (resection of the front of the foot), "and found it to answer perfectly my expectations. I made a mark across the upper part of the foot, to point out as exactly as I could the place where the metatarsal bones were joined to those of the tarsus. About half an inch nearer the toes I made a transverse incision through the integuments and muscles covering the metatarsal bones. From each extremity of this wound I made an incision (along the inner and outer sides of the foot) to the toes. I removed all the toes at their junction with the metatarsal bones, and then separated the integuments and muscles forming the sole of the foot from the inferior part of the metatarsal bones. . . I then separated with the scalpel the four smaller metatarsal bones at their junction with the tarsus, which was easily effected, as the joints lie in a straight line across the foot. The projecting part of the first cuneiform bone, which supports the great toe, I was obliged to divide with a saw."

Hey himself appears to have been a little indefinite about the procedure that bears his name, for in one of the instances he dissected out all the metatarsal bones, and in another he drew the saw across the bases of those bones.

A modification of this operation, practised by the late

Prof. R. W. Smith, is thus described by Sir William Stokes. It is claimed as an advantage that the two anterior points of support—viz., the ball of the great toe and the base of the fifth metatarsal bone—are preserved.

"The operation is performed by making an oblique incision across the four lesser metatarsal bones, commencing about three-fourths of an inch in front of the base of the fifth metatarsal bone, and in a direction towards the metatarso-phalangeal articulation of the great toe. The incision should be made down to the bones, and another incision should then be made at the centre of the first one, but at right angles to it, upwards and inwards, for about an inch or an inch and a quarter. The tissues at each side of the second incision should then be dissected off the bones, and these, thus freely exposed, should be obliquely divided close to their proximal articulations with a small saw or fine forceps. The flap should be taken altogether from the sole of the foot" (Heath's "Dictionary of Surgery," vol. i., page 551).

For the after-treatment of these operations, *see* page 442.

CHAPTER XXIV.

PARTIAL AMPUTATION OF THE FOOT.

AMPUTATION THROUGH THE MEDIO-TARSAL JOINT (CHOPART'S OPERATION).

THIS consists of a disarticulation of the foot at the medio-tarsal joint. The procedure that at the present day is known by this name differs somewhat in detail from the operation as originally described by Chopart.

Anatomical Points.—The medio-tarsal joint consists of two articulations—the calcaneo-cuboid on the outer side, and the astragalo-scaphoid on the inner. These two joints have distinct synovial membranes. They lie nearly in a transverse line, but the astragalo-scaphoid joint is more convex anteriorly, and is a little in advance of the companion articulation. The first-named articulation forms a ball-and-socket joint, the convex head of the astragalus being secured in the concave facet of the scaphoid (Fig. 111). The greatest vertical measurement of the articulation is one inch, while its greatest transverse measurement is about the same. The following ligaments support the joint:—(1) The astragalo-scaphoid, a thin dorsal ligament; (2) the inferior calcaneo-scaphoid, a dense, thick fibrous plate, that lies just under the joint; (3) the external calcaneo-scaphoid. This band lies in the hollow between the two joints of the medio-tarsal line. It starts from the os calcis, and blends above and below with the two ligaments already named. It is called by the French the Y ligament, "la clef de l'articulation de Chopart." The synovial membrane of

Fig. 111.—BONES OF THE FOOT.
A A, Line of Chopart's Amputation.

this joint is common also to the anterior astragalo-calcaneal articulation.

The calcaneo-cuboid joint presents a concavo-convex surface the concavity inclining from above downwards and inwards. It measures about three-quarters of an inch vertically, and one inch transversely. It is supported by the following ligaments:—(1) The internal calcaneo-cuboid, a strong band; (2) the dorsal calcaneo-cuboid, a wider ligament; and (3) and (4), the well-known long and short plantar ligaments. The synovial membrane is peculiar to the joint. This articulation lies on a line midway between the tip of the external malleolus and the tuberosity of the fifth metatarsal bone. The companion joint will be found just behind the tuberosity of the scaphoid—a conspicuous landmark.

Fig. 112.—CHOPART'S AMPUTATION.

Instruments and Position. — The same as for Lisfranc's operation. The surgeon should sit to cut the plantar flap, but will find it more convenient to stand while cutting the dorsal flap and while disarticulating.

Operation.—In its main points the procedure is identical with Lisfranc's amputation. 1. *The dorsal flap.*—The incision commences at a point midway between the tip of the outer malleolus and the tuberosity of the fifth metatarsal on the outer side, and at a point just behind the tuberosity of the scaphoid on the inner side. The cut follows on either side the margin of the foot for a little distance, and is then so curved over the dorsum as to cross the bases of the metatarsal bones (Fig. 112). 2. *The plantar flap* extends between the two points first named. It follows in the main the lines of Lisfranc's flap, and has the same shape. It is so carried over the sole as to cross the middle of the metatarsus (Figs. 112 and 118, B). The flexor tendons are divided as soon as a little skin has been retracted. Both flaps contain all the soft parts down to the bones. The medio-tarsal joint-line should be well exposed.

3. *The Disarticulation.*—In disarticulating, the foot may be conveniently held in the position of talipes varus, and be well extended. Care must be taken to open the right joints. It is easy to open the scapho-cuneiform joints in the place of the astragalo-scaphoid, and to actually leave the scaphoid behind.

The tendons that are especially to be noted in cutting the deeper parts are the three peronei and the two tibials.

Hæmorrhage.—In the dorsal flap, the dorsalis pedis artery is cut as it dips down between the first and second metatarsal bones. The metatarsal and tarsal branches of that vessel are also divided. The two saphenous veins come in this flap.

At the anterior part of the inner segment of the plantar flap the internal plantar artery is divided, and near the base of the second metatarsal bone the end of the external plantar. In the outer part of the flap are the digital branches of the latter vessel.

Fig. 113.—ANATOMY OF THE STUMP AFTER CHOPART'S AMPUTATION. (*Farabeuf.*)

Comment.—The value of this operation is open to serious question, and in many points it does not compare favourably with Syme's amputation. It is not adapted for cases of bone-disease as a rule. The stump may appear an excellent one immediately after the operation. In process of time, however, it will be found that the whole of the os calcis—and not the tuberosities merely—is brought in contact with the ground, and that the somewhat sharp-edged anterior part of the bone is not well suited to bear pressure.

In some cases the stump has a tendency to turn over into what would be the varus position, and the patient walks upon the outer border of the under surface of the os calcis.

In other instances—and these are not uncommon—the heel is drawn up by the action of the tendo Achillis, the head of the os calcis is tilted downwards, and upon this point of bone the patient walks (Fig. 113). A stump so deformed will be painful, and will probably become too tender to bear the weight of the

body; or the cicatrix, being exposed to pressure, may break down.

Attempts have been made to prevent this mal-position by attaching the anterior tendons, including especially the tibialis anticus, by stout sutures, to the tissues of the sole-flap.

It has been further recommended that a wedge-shaped pad be worn in the boot, so placed as to resist the turning-down of the head of the os calcis. Finally, the tendo Achillis has been divided. This tenotomy, while it has weakened the foot greatly, has not always sufficed for the permanent cure of the deformity. (*See* Tripier's Operation, page 453.) In some cases caries of the os calcis appears to have supervened.

The planning of the flaps may be varied. If the dorsal flap be curtailed, the plantar flap must be increased in length. Some surgeons, having made the dorsal flap, and effected the disarticulation, cut the plantar flap by transfixion. Such a flap, however, is apt to be ill-shaped and thin, and the plantar arteries will be probably divided unnecessarily high.

It has been advised to leave the scaphoid bone when sound, and so to retain the attachment of the tibialis posticus. To effect this end the flaps must be cut longer on the inner side. It has not been shown that this modification is of special value. (For the after-treatment, *see* page 442.)

CHAPTER XXV.

Partial Amputation of the Foot.

SUBASTRAGALOID DISARTICULATION.

This operation consists of a disarticulation at the astragalo-scaphoid and astragalo-calcaneal joints. The astragalus is the only bone of the foot that is left behind, and forms the summit of the stump.

Anatomical Points.—The astragalo-scaphoid joint has been described (page 431). (*See* also Fig. 111.)

The os calcis articulates with the astragalus by a double joint; the anterior communicates with the medio-tarsal articulation; the posterior is separate and complete in itself. The two bones each present two articular facets of unequal size, separated by a deep groove, in which is lodged the interosseous ligament. This groove and ligament divide the anterior from the posterior joint. In front of the inner end of the groove the prominent process—the sustentaculum tali—projects inwardly. The posterior facet is the larger, is convex on the os calcis, concave on the astragalus, and is about one inch and a half in length, and three-quarters of an inch in width. The anterior facet is narrower, smaller, and more internal. It is concave on the os calcis, and runs on to the upper surface of the sustentaculum tali, while it is convex on the astragalus.

The under-surface of the astragalus, as seen after the disarticulation, is, speaking generally, flat, and forms an even surface for the end of the stump. The groove between the facets runs obliquely from within forwards and outwards.

The following are the ligaments between the os calcis and astragalus. The main connection is effected by the very massive interosseous ligament which occupies the whole length of the groove. On the outer side are the membranous external calcaneo-astragaloid and external calcaneo-scaphoid

ligaments, and a part of the external lateral ligament of the ankle. Behind is the posterior calcaneo-astragaloid ligament, and on the inner side the internal ligament of that name, together with part of the internal lateral ligament of the ankle.

Position and Instruments.—The same as in the preceding operation.

The following **methods** will be described:—

1. Farabeuf's operation.
2. The oval operation.
3. Verneuil's operation.
4. By the heel flap.

1. Farabeuf's Operation by a Large Internal and Plantar Flap.

In this procedure a large flap is cut from the sole and the inner aspect of the foot.

(1) *The Line of Incision.*—The incision is commenced at the outer margin of the tendo Achillis at its insertion (Fig. 114, A), and is then curved up a little to reach the level of a point one inch below the outer malleolus. It is now carried forwards horizontally, parallel to the outer border of the foot, and one inch below the malleolus (A to B), and reaches a point (B) which is on a line connecting the base of the fifth metatarsal bone with the joints between the scaphoid and cuneiform bones. It then curves sharply inwards across the dorsum of the foot (B to X), a little in front of the joints named, and reaches the extensor proprius pollicis tendon at X. The incision next crosses the inner border of the foot so as to follow the line of the cuneo-metatarsal joint of the great toe (X to C).

It now sweeps across the centre of the sole of the foot (C to D), and is then rounded off and curved back, so as to follow exactly the outer border of the foot as far as the external tuberosity of the os calcis (E). It is now curved up a little to end at the insertion of the tendo Achillis at A. (*See* also Fig. 118, E and Fig. 121, A.)

The foot must be turned from side to side by the surgeon's left hand as the devious line of this incision is followed. The knife at first divides only the skin and the subcutaneous tissue. It is then made to follow the incision a second time—when the skin has retracted a little—and is carried to the bone. Care must be taken that the knife goes well down to the bone,

and that all the soft parts are divided. To effect this the blade must be used with considerable vigour. The border or surface of the foot that is attached must be put upon the stretch, so that the tendons are cleanly divided. The peronei tendons are especially difficult to cut. In making these deep sweeps with the knife great care must be taken to avoid opening any

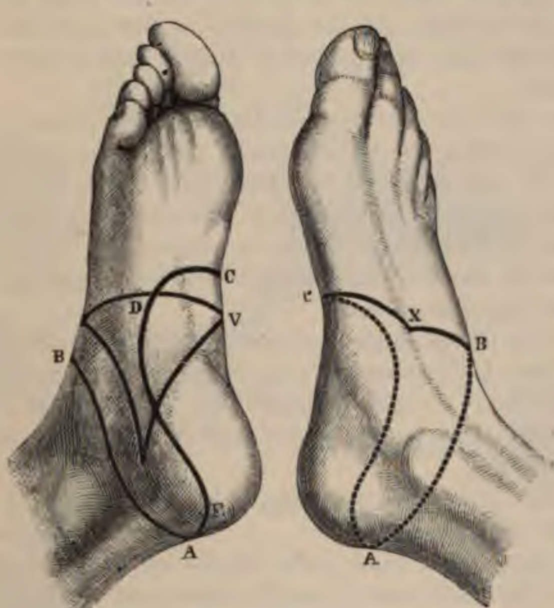

Fig. 114.—INNER AND OUTER SIDES OF THE RIGHT FOOT, TO SHOW THE INCISIONS IN FARABEUF'S SUBASTRAGALOID AMPUTATION.
V, The lines of Verneuil's subastragaloid amputation. (For other references, *see* Text.)

joints, notably those between the scaphoid and the cuneiform bones.

(2) *The Disarticulation.*—The leg having been flexed upon the thigh, the assistant turns the knee in with one hand and presses the lower part of the leg against the edge of the couch with the other.

The foot projects beyond the end of the table, with its outer surface well exposed and lying horizontally.

Let the dorsal part of the flap (X to A) be now dissected up sufficiently to well expose the head of the astragalus;

divide the tendo Achillis; open the astragalo-scaphoid joint on its dorsal aspect. Keep the knife between the bones, and, cutting backwards, pass it between the os calcis and astragalus, and so sever the interosseous ligament. This entails no difficulty if the outer surface of the foot be well exposed and kept upon the stretch with the left hand. As the ligament is divided, turn the os calcis more and more out. See that all the tendons, etc., are divided on the outer side of the foot, and that the outer aspect of the os calcis is bared to the periosteum.

Now with the left hand twist the foot round until it is in the position of the extremest varus. In this position dissect—by cuts made from left to right in the left foot, and from right to left in the right foot—all the soft parts from the inner and under surfaces of the os calcis (Fig. 115). Special care must be taken of the vessels which lie in the hollow on the inner side of that bone.

Clear the under surface of the bone, still turning the foot out. When this process of enucleation is complete, the foot will have been so turned round that the dorsum will face downwards. Now separate the foot and cut any neglected tendons short.

The suture line on the stump is horizontal, and is on the outer side of the extremity.

The operation is much easier on the left than on the right foot. In the latter case it may be more convenient to dissect up the great flap and bare the os calcis before the disarticulation is effected.

A hole may be made in the heel part of the flap—which forms a pouch—and a drainage-tube passed through it.

Hæmorrhage.—In the part of the flap A to B are cut the posterior peroneal, the anterior peroneal, and branches of the tarsal and metatarsal arteries. The largest of these is the first-named, which runs just behind the malleolus.

In the part B to X the tarsal artery and the dorsalis pedis—the latter a large vessel—are divided opposite the centre of the head of the astragalus. In the part X to D the internal and external plantar are cut. In the margin of the flap D to E branches of the latter vessel are found.

2. **The Oval Operation (Maurice Perrin).**—The incision in

this procedure commences behind, at the insertion of the tendo Achillis, and is carried forwards along the outer side of the foot—parallel with its external border, and one inch and a half below the external malleolus—to a point just behind the base of the fifth metatarsal bone.

It is then curved across the dorsum to reach on the

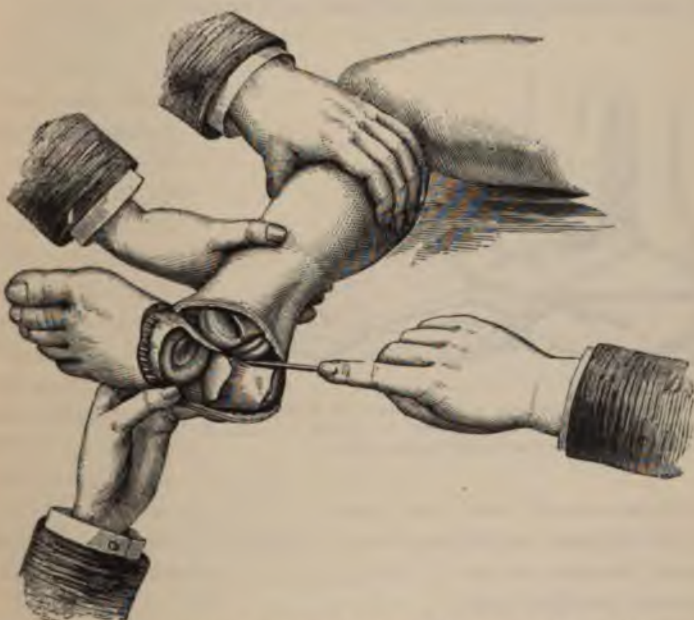

Fig. 115.—SUBASTRAGALOID AMPUTATION OF THE LEFT FOOT. (*After Farabeuf.*)

inner side of the foot the level of the joint between the first metatarsal bone and the cuneiform. The incision now sweeps back across the sole and joins the first cut some two inches behind the base of the fifth metatarsal bone (Fig. 116, B).

The incision may at first involve the skin only, but must then be carried well to the bone.

The subsequent steps of the operation are precisely the same as in the previous amputation. The foot should be placed in the same posture, and the disarticulation effected in the same manner.

It is advisable to saw off the head of the astragalus.

In the left foot the disarticulation may be carried out as soon as the dorsal and external parts of the flap have been dissected back. In the right foot the whole of the flap had better be dissected back as far as possible, and the os calcis cleared before the disarticulation is attempted.

3. **Verneuil's Operation.**—This procedure appears to be one that is very generally adcpted in France (Fig. 114, v).

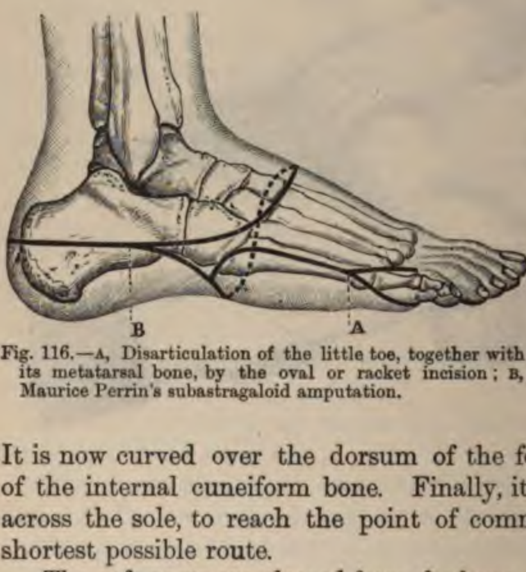

Fig. 116.—A, Disarticulation of the little toe, together with its metatarsal bone, by the oval or racket incision; B, Maurice Perrin's subastragaloid amputation.

The incision is commenced over the outer tuberosity of the os calcis, from 2 to 3 c.m. below the external malleolus. It is then carried forward to a point 2 c.m. behind, and to the inner side of the base of the fifth metatarsal bone. It is now curved over the dorsum of the foot to the middle of the internal cuneiform bone. Finally, it sweeps obliquely across the sole, to reach the point of commencement by the shortest possible route.

The soft parts are cleared from the bone, and the disarticulation effected as above described. It is advisable to saw off the head of the astragalus.

4. **Disarticulation with a Heel Flap.**—The flaps made in this operation are a modification of those of Syme's amputation (page 445). The plantar incision commences half an inch below the outer malleolus, and ends one inch below the inner malleolus. Between these points it is carried vertically downwards across the heel, while the foot is held at right angles to the leg. The dorsal flap is U-shaped, has its limbs horizontal, and crosses the foot, with a curve, at the level of the astragalo-scaphoid joint (Fig. 117, B).

The heel flap is dissected back just as in Syme's amputa-

tion (page 446), and the tendo Achillis is then divided. The dorsal flap is in the next place dissected up, and must include all the soft parts down to the bone.

The astragalo-scaphoid joint having been opened from the dorsum, the knife is passed between the astragalus and os calcis, and the disarticulation is effected. Ashhurst advises that, as soon as the flaps have been made, the anterior part of the foot should be disarticulated along the line of Chopart's operation, that the os calcis should then be grasped with a pair of lion forceps and twisted from side to side while the separation from the astragalus is effected.

Fig. 117.—A, Disarticulation of the great toe, together with its metatarsal bone, by the oval or racket incision; B, subastragaloid amputation by heel flap.

The head of the astragalus should be removed with the saw. The vessels divided are practically the same as those cut in Syme's operation.

Comment.—Subastragaloid amputation was proposed by Lignerolles in 1839, was first performed in Germany by Textor in 1841, in France by Malgaigne in 1845, and in England by Simon in 1848. Malgaigne employed a single large internal flap, and Nélaton peculiar dorsal and plantar flaps that were larger on the inner than the outer side.

The amputation gives very excellent results. The astragalus forms a good surface for support, and, as the ankle-joint is preserved, a more elastic stump is produced than results from either Syme's or Pirogoff's amputation.

Of the four methods described, the first three are practically varieties of the oval or racket incision, the last involves a simple heel flap.

Farabeuf's operation has been considered first because it

serves to demonstrate the especial features of the operations by the oval method and the difficulties of disarticulating. The resulting flap affords an excellent covering to the bone, the head of the astragalus can be left, and the cicatrix is well removed from pressure. The incision is, however, needlessly complex, the flap is a little unwieldy, a rather large pocket is formed about the heel, and it is not easy to obtain in every case so large a tract of sound skin as is demanded. Verneuil's operation is much simpler, but, if conducted precisely upon the lines laid down, the resulting flap is a little scanty. So far as my experience goes, I should say the choice of a subastragaloid amputation rested between the procedure of Maurice Perrin and that by the heel flap. I have once had the opportunity of performing both operations at the same time, upon the same patient, for troubles following upon extreme talipes varus.

Perrin's operation is difficult; the soft parts are somewhat roughly handled, and there are many risks of injuring the vessels of the flap. The wound will probably not heal so well as after the operation by the heel flap. The latter procedure is simple, is easy, and can be carried out with a minimum amount of disturbance to the soft parts. The wound heals readily.

When the stumps, however, have become firm, some important points of difference are to be noted:—The stump in the oval operation is wide, and the cicatrix is well removed from pressure; in the heel-flap procedure the stump is narrower, and the suture line comes inconveniently near to the pressure area. In patients in whom excellent healing powers may be expected, I think Perrin's method is to be preferred.

In these operations a drainage-tube may be retained for one or two days. The limb should be supported on an inclined plane on a simple back-splint. The sutures should be retained as long as possible, and after their removal the flap may be supported by strapping.

THE AFTER-TREATMENT OF PARTIAL AMPUTATIONS OF THE FOOT.

The wound should be kept exposed to the air for reasons already given (page 69), the limb should be a little raised upon a pillow, and the stump should be so placed that efficient

drainage is permitted. The remarks already made with reference to the after-treatment of amputations of the toes apply to certain of these operations (page 416).

In the case of the removal of the great toe, together with its metatarsal bone, the foot should be allowed to lie a little upon its inner side, provided that direct pressure is not made upon the wound. When the fifth toe has been removed in a similar manner, the foot should be inclined towards the opposite side.

After Lisfranc's and Hey's amputations the limb may be allowed to lie upon one or other side with the knee bent. The pillow supporting the foot should be firm, the stump may project a little beyond the end of the pillow, and to this support the leg may be lightly secured.

After Chopart's operation and after the subastragaloid amputations the stump should be supported, upon a back-splint, which is kept a little raised by a firm pillow or cushion. By this means the heel-flap is supported, and the os calcis in the Chopart operation is to a great extent kept from altering its position. The knee should be a little bent, and the stump may be inclined laterally, so as to favour drainage. The splint employed is an ordinary straight back-splint, suitably padded.

A pad is introduced beneath the tendo Achillis. The skin is protected by a piece of gutta-percha moulded to the limb and lined with lint. The splint is secured by straps and buckles (Fig. 76).

Drainage-tubes should not be employed unless actually necessary, and should never be passed right across the angle of the wound, from one extremity of the incision to the other. A small piece of tubing may be introduced at each of the two corners of the wound—as in Hey's, Lisfranc's, and Chopart's amputations—and sutures at these points may be omitted. In any case the tubes should, under ordinary circumstances, be removed in twenty-four hours.

In the subastragaloid operations, where a heel-flap exists—with a pouch left by the removal of the os calcis—a hole may be made through the centre of that flap into the pouch, and a short length of tube introduced. This need not be retained more than one day.

CHAPTER XXVI.

Amputation of the Foot.

Two procedures will be described:—

A. Disarticulation at the ankle-joint.
B. Intra-calcaneal amputations of the foot.

A.—DISARTICULATION AT THE ANKLE-JOINT (SYME'S AMPUTATION).

This is the principal operation for removing the entire foot. The flap is made from the heel, the soft parts having been peeled off the os calcis. The two malleoli, together with the articular surface of the tibia, are sawn off.

Anatomical Points.—The mechanical characters of the ankle-joint should be well known, and the height and breadth of the dome on the tibia, which receives the head of the astragalus, duly appreciated.

The anterior and posterior ligaments of the ankle-joint are very thin, but the lateral ligaments—and especially the internal lateral ligament—are very strong, and have wide and extended attachments to the tarsal bones. The chief tendons about the ankle-joint run in synovial sheaths, and are therefore difficult to cut unless the knife be wielded with vigour.

The *blood supply* of the heel-flap is a matter of great importance; the two chief vessels of supply are the external calcaneal of the posterior peroneal on the outer side, and the internal calcaneal of the external plantar on the inner side. The first-named vessel is a continuation of the posterior peroneal. It runs just behind the inferior tibio-fibular joint, and then behind the outer malleolus to the heel. With regard to the internal calcaneal artery, the posterior tibial divides "on a level with a line drawn from the point of the internal malleolus to the centre of the convexity of the heel." This line is dangerously close to the line of the incision. The internal calcaneal artery arises from the external plantar, close to the bifurcation and under the fibres of origin of the abductor

pollicis. Inasmuch as this is the chief vessel of the flap, the greatest care must be taken of it. (*See* page 448.)

Minute branches may reach the flap from the internal malleolar of the posterior tibial and from the outer and inner malleolar of the anterior tibial.

The lower *epiphysis* of the tibia includes the articular surface and the inner malleolus. It joins the shaft between the eighteenth and nineteenth years. The lower epiphysis of the fibula corresponds to the outer malleolus, and joins the shaft about the twenty-first year.

The os calcis has an epiphysis for its posterior extremity It forms a cartilaginous shell for that part of the bone. It does not commence to ossify until the tenth year, and does not join the body of the bone until fifteen or sixteen.

In removing the lower ends of the tibia and fibula the greater part of the anterior and posterior tibio-fibular ligaments, together with the interosseous ligament, are saved, while the transverse or inferior ligament is cut away with the bones.

Instruments.—A stout narrow knife, with a blade three inches long, a narrow but rounded point, and a large strong handle; a scalpel; a saw; two metal retractors to hold back the flaps when sawing the leg bones; lion forceps; pressure forceps; artery and dissecting forceps, scissors, etc.

Position.—The patient lies on the back, with the foot projecting beyond the end of the table, and the toes pointing upwards. The surgeon sits facing the end of the table. The lower end of the leg is raised on a Volkmann's pelvic support to the level of the surgeon's face. The surgeon sits to cut the heel flap, and stands to cut the dorsal flap and to disarticulate. Two assistants stand facing the surgeon, one on each side of the end of the table. One steadies the foot, the other attends to the wound.

The Operation.—An assistant steadies the leg with one hand, and holds the foot—by the toes—rigidly at a right angle to the leg with the other hand.

1. *The Heel Flap.*—The incision starts from the tip of the outer malleolus, and in a line nearer to its posterior than its anterior border.

It is carried vertically down the heel, exactly at right angles to the long axis of the foot, runs transversely across

the sole, and passing up vertically on the inner side of the heel, ends at a point about half an inch below the tip of the inner malleolus (Fig. 118, D).

In making this incision, supposing the right foot to be operated on, the surgeon holds the ankle with the palm of his left hand on the dorsum of the foot, with his thumb on the outer malleolus, and his forefinger on the inner malleolus.

Fig. 118.—PLANTAR INCISIONS. A, Lisfranc; B, Chopart; C, Pirogoff; D, Syme; E, Farabeuf's subastragaloid amputation; F, Farabeuf's amputation at the ankle.

Entering the knife at the inner starting-point, the incision is carried down to the sole and then across the plantar aspect of the os calcis at one cut. The knife is now re-entered at the outer starting-point, and is carried down to meet the first incision at the sole. If an attempt be made to perform the incision at one cut, and to make the outer limb of the incision by cutting from the heel towards the leg, the knife may slip and cut too far up into the leg, running by the starting-point. On the left foot the same precaution is observed, but the incision is commenced on the outer side.

This incision should be carried well and cleanly down to the bone. The heel flap is now dissected back: the thumb-nail of the left hand is used with force to drag back the soft parts, while the knife is kept well on to the bone and parallel to the surface of the flap. The os calcis must be laid perfectly bare. The great point in Syme's amputation is to "keep close to the bone."

The flap must be cleared from the tuberosities of the os calcis, and then from its posterior surface.

2. *The Dorsal Incision.*—The surgeon now holds the foot in the left hand in the position of the full extension, and connects the extremities of the heel incision by a cut which simply sweeps across the front of the ankle region. The dorsal and the heel incisions are about at right angles to one another

(Fig. 119). The cut includes all the soft parts down to the bone. The tendons must be cleanly divided while the foot is kept on the stretch.

3. *The Disarticulation.*—The ankle-joint is at once exposed, the anterior ligament having been severed. The knife is now introduced into the joint and the lateral ligaments are divided, in both instances by cutting from within outwards. These complex ligaments are difficult to cut if attacked from the outer side of the articulation. The posterior ligament is cut, the upper surface of the os calcis is cleared, and by the division of the tendo Achillis the disarticulation is completed.

4. *The Removal of the Malleoli.*—The soft parts are cleared from the two malleoli and the lower end of the tibia, great care being taken not to damage the flaps. The exposed bones are then divided by a horizontal saw-cut, the saw being applied about a quarter of an inch above the inferior margin of the tibia.

Fig. 119.—SYME'S AMPUTATION OF THE FOOT.

The flaps may be protected by spatulæ during the sawing. If it should be necessary, the malleoli may be held with lion forceps.

Before the wound is adjusted by sutures, a hole may be made in the centre of the heel flap, and a drainage-tube introduced.

Hæmorrhage.—The anterior tibial artery is cut in the dorsal flap just opposite the centre of the front of the ankle. The external and internal plantar arteries are divided in the inner section of the heel flap. The two vessels are close together. The following vessels may give rise to hæmorrhage: the internal malleolar of the posterior tibial behind the inner malleolus; the anterior peroneal in front of the tibio-fibular joint; the external and internal malleolar of the anterior tibial in front of their corresponding malleoli. The internal saphenous vein is cut in the dorsal flap, the external in the heel flap.

Comment.—This amputation gives admirable results, and secures a sound and firm stump. The patient walks upon

the natural tissues of the heel. The tendo Achillis forms an attachment with the mass of the cicatrix. With a properly adapted boot, a patient after Syme's amputation can walk with little appreciable lameness.

The mortality of this operation in 338 cases is 9·7 per cent. (Ashhurst).

The following special points in the operation must be noted :—

1. It is important that the flap should be accurately cut. In some text-books it is advised that the incision be carried from the tip of the outer malleolus to a point half an inch *behind* and below the inner malleolus. If this be done, there is great probability that the posterior tibial artery will be divided before its bifurcation, and the main artery of the flap (the internal calcaneal of the external plantar) be thus lost.

The following are Syme's own words :—"The incisions *must* be correctly made. A transverse one should be carried across the sole of the foot, from the tip of the external malleolus, or a little posterior to it (rather nearer the posterior than the anterior edge of bone) to the opposite point on the inner side, which will be rather below the tip of the internal malleolus." Thus the inner part of the heel flap is a little larger than the outer.

If the flap be too large, there is great difficulty in dissecting it back, and it will probably be dangerously scored and bruised in the attempt.

2. In clearing the os calcis, the periosteum may be at the same time peeled off—as many advise—and so made to form an important constituent of the heel flap. In young subjects (under the age of fourteen years) the posterior epiphysis of the os calcis may be detached and left undisturbed in the flap.

In such subjects it generally comes away during the process of clearing the os calcis.

In still younger patients—say those under ten—the superficial parts of the os calcis will be found imperfectly ossified, and chunks of the soft bone may be cut away in a too vigorous clearing of the heel flap.

3. It is desirable that all the articular surface of the tibia should be removed, and, as the under-surface of the bone is much domed, the section must be made as high up as a quarter

of an inch to quite clear the summit of the concavity. In young patients the whole of the lower epiphysis may be removed by a too liberal use of the saw; the measurement (quarter of an inch) refers to adults.

Other Methods.

Roux's Operation.—This is a modified form of the oval method.

The dorsal incision is commenced at the posterior edge of the outer face of the os calcis, is carried forwards just below the external malleolus, and then crosses the dorsum of the foot one inch in front of the ankle-joint, to a point between the tubercle of the scaphoid and the inner malleolus, and on a level with the tip of the latter process (Fig. 120).

Fig. 120.—ROUX'S AMPUTATION.

The plantar incision starts from the last-named point, and curving forwards a little, crosses the inner border of the foot, at about the level of the scaphoid. It is then carried across the sole to a point about one inch behind the tuberosity of the fifth metatarsal bone, and thence up to the *point de départ*. The flaps are dissected back as far as possible, the foot is disarticulated, and the soft parts are then dissected away from the inner side of the os calcis in somewhat the same manner as is described in Farabeuf's subastragaloid amputation.

The malleoli are removed as in Syme's amputation.

The procedure is difficult and tedious, and is, on the whole, inferior to Syme's operation. The flap, if well cut, is certainly better nourished, but a greater demand is made upon the integuments of the foot.

Farabeuf's Operation.—In all essential points this operation is identical with the subastragaloid amputation of the same surgeon (page 436).

The incision is commenced on the outer side at the insertion of the tendo Achillis. It is carried horizontally forward (touching the tip of the external malleolus) to a point just in front of the calcaneo-cuboid joint (corresponding to B, Fig. 114). It then crosses the dorsum to reach the extensor proprius pollicis tendon, just in front of the astragalo-scaphoid joint (corresponding to X, Fig. 114). It now sweeps over the inner border of the foot, crossing the scapho-cuneiform joint (corresponding to X to C, Fig. 114 and B, Fig. 121), and is then carried back along the median line of the sole (corresponding to D to E, Fig. 114, and F, Fig. 118), to end at the insertion of the tendo Achillis. The flaps are dissected back as far as convenient, the ankle-joint is opened from the outer aspect of the foot, and the disarticulation and the clearing of the os calcis are effected precisely in the manner already described.

A good thick vascular flap is provided, but the operation is less easy to execute than Syme's, and has no distinct advantage over that admirable procedure.

B.—INTRA-CALCANEAL AMPUTATIONS OF THE FOOT.

Pirogoff's Operation.—This operation closely resembles Syme's, save that the os calcis is sawn through, and its hinder part is left in the heel flap. The lower ends of the tibia and fibula are sawn through, and to this cut surface of bone the surface of the divided os calcis is adjusted.

The operation usually described is a modification of Pirogoff's original procedure. Pirogoff divided the calcaneum vertically, and left the articular surface of the tibia, unless it was diseased.

Position and *Instruments.*—The same as in Syme's operation. The saw should either be a fine Butcher's saw, or a slender saw with a movable back. Retractors are required.

Operation.—The incisions are nearly the same as in Syme's operation, with these modifications:—They commence on the outer side, just in front of the tip of the malleolus, and end on the inner side a few lines in front of the internal process. The heel incision is carried a little farther forward than in Syme's operation (Fig. 118, C). It is carried well down to the bone.

The soft parts are dissected backwards from the os calcis for about a quarter of an inch.

The dorsal cut is then carried out, and may be a little more convex than in Syme's amputation. The ankle-joint is opened, and disarticulation effected precisely as already described.

The foot is now dragged forward and placed in the position of full extension.

The whole of the upper surface of the os calcis is exposed. The saw is now applied to this surface, one finger's-breadth behind the astragalus, and is made to cut the bone obliquely, following the lines of the now distorted heel - incision. In sawing the bone, the soft parts must be carefully retracted, and, in the position in which the foot is held, the saw runs nearly vertically (Fig. 121, C). The greatest care must be taken not to damage the arteries in the inner part of the heel flap.

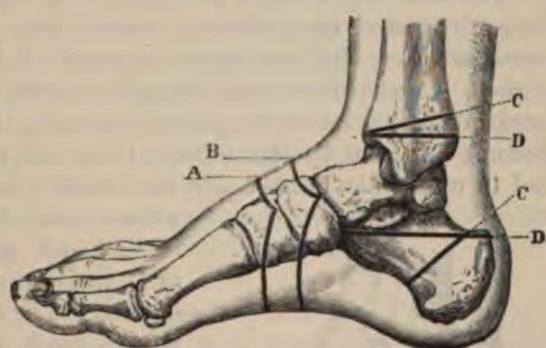

Fig. 121.—A, Farabeuf's subastragaloid amputation; B, Farabeuf's amputation at the ankle-joint; C C, Saw-cuts in Pirogoff's operation; D D, Saw-cuts in Pasquier and Le Fort's operation; D shows also the saw-cut made in the os calcis in Tripier's operation.

The soft parts are now dissected from the lower ends of the tibia and fibula. The saw is applied to the anterior aspect of these bones, close to the articular surface of the tibia, and is made to cut so obliquely upwards that the saw emerges on the posterior aspect of the tibia, a finger's-breadth above the articular surface (Fig. 121, C). Any unduly long tendons are divided. The wound is sutured as in Syme's operation, the cut surfaces of bone being thus brought into close contact.

Care must be taken in the after-treatment that the heel fragment is not drawn up by the tendo Achillis.

The vessels divided are the same as in the preceding operation.

Comment.—Some surgeons make much larger heel flaps, carrying the incision forwards and downwards, so as to cross the calcaneo-cuboid joint, instead of directing it nearly vertically downwards from the malleoli.

This operation does not appear to have been very widely employed. It is suited for certain cases of accident, but not for cases of disease.

It presents these advantages when compared with Syme's operation :—

The heel flap is much less likely to slough; the stump is longer by one or two inches, is firmer, does not shrink, and contains bone; the insertion of the tendo Achillis is not disturbed. On the other hand, Pirogoff's operation is no easier to perform than Syme's; the piece of bone in the heel is apt to become displaced by the action of the calf muscles; it may fail to unite, may necrose, and has led to a painful stump; a wider section of cancellous bone is left, and greater demands are made upon the healing powers. The operation would not be likely to succeed with elderly subjects. So far as movement is concerned, it has not been shown that the stump is always very decidedly improved by the retention of a portion of the calcaneum.

Fig. 122.—PASQUIER AND LE FORT'S OPERATION.

Le Fort's Operation.—This is a modification of Pirogoff's procedure. It is described by Farabeuf as "Pasquier-Le Fort's operation."

The skin incisions are somewhat the same as in Roux's method, with the exceptions that the incision on the outer side is carried back to the insertion of the tendo Achillis and the wound-lines conform to the racket rather than to the oval operation (Fig. 122).

The calcaneum is cut horizontally just below the sustentaculum tali (Fig. 121, D).

The incision having been carried to the bone, the soft parts are dissected back as far as possible, especially on the dorsum and about the external part of the wound. The ankle-joint is opened from the outer side, the anterior and external ligaments being first attacked. The disarticulation is made complete, and the foot rotated very strongly outwards, so that the astragalus presents at the outer part of the wound.

The astragalus is now seized with large lion forceps and turned (together with the whole foot) still more outwards, until at last the forceps are quite horizontal. The upper portion of the os calcis is carefully cleaned, and all the part of the bone that requires removal will now be seen in the outer wound, the inner surface of the os calcis looking directly upwards. The saw is applied to the surface, just below the sustentaculum tali, and the bone is divided quite horizontally. The insertion of the tendo Achillis is preserved. The inferior and lateral ligaments of the calcaneo-cuboid joint having been divided, the foot is free.

The lower ends of the tibia and fibula are sawn through horizontally, just above the articular surface for the ankle-joint (Fig. 121, D).

It is claimed that this procedure is superior to Pirogoff's, on the following grounds:—A good thick flap, well supplied with blood, is provided. A larger amount of the soft parts that cover the heel is saved. The whole length of the os calcis rests upon the ground, and the patient is provided with a wider area of support. The parts are left in a more natural position.

Tripier's Operation.—This operation is really a modification of Chopart's amputation.

In that procedure some difficulty is often experienced by the tilting of the heel-stump in the position of talipes equinus. Tripier seeks to avoid this by making a wide horizontal section of the os calcis, so that the stump may present a broad and level basis of support. An excellent flap is provided.

The dorsal incision has its concavity upwards and inwards. It commences at the outer edge of the tendo Achillis, on a level with the tip of the external malleolus. It sweeps forwards about one inch below that point of bone, passes a finger's-breadth behind the tuberosity of the metatarsal bone,

and ends at the inner side of the extensor proprius pollicis tendon, two fingers'-breadths in front of the ankle-joint. The plantar incision commences at this point, is carried over the inner cuneiform bone at the internal margin of the foot, sweeps with a curve across the sole, reaches the outer edge of the foot about the base of the fifth metatarsal, and then joins the dorsal incision (Fig. 123).

The incision extends to the bone. The flaps are dissected back so as to make clear the medio-tarsal joint. Disarticulation is now effected as in Chopart's operation. With a rugine the whole of the under part of the os calcis is bared of periosteum, the plantar flap having been dissected up as high as the sustentaculum tali. The os calcis is now seized with lion forceps and so turned as to well expose its inner surface. The saw-cut is made horizontally, just below the sustentaculum, and runs from the inner to the outer surface (Fig. 121, D). The angle which the cut surface of the os calcis forms with the cuboid surface of that bone is finally rounded off with the saw, and the operation is complete.

Fig. 123.—TRIPIER'S OPERATION.

THE AFTER-TREATMENT OF AMPUTATIONS OF THE FOOT.

Many of the observations already made with reference to the after-treatment of amputations of the toes and of portions of the foot apply to the present procedures.

The stump should be kept exposed to the air.

The limb should be a little raised upon a firm pillow.

A back-splint should be adjusted precisely as advised in the case of some of the previous operations (page 309, Fig. 76).

Care must be taken that the pad of the splint does not press unduly upon the extremity of the stump. This splint serves to support the heel flap, and, in the case of the intra-

calcaneal amputations, it helps also to keep the osseous surfaces in contact, and to restrain the action of the muscles of the calf.

The knee should in all instances be a little bent, and the stump may, when required, be inclined a little laterally, to favour drainage.

Drainage-tubes should not be employed when their use can be avoided. They should never be passed—as is sometimes done in Syme's operation—right across the angle of the wound from one extremity of the incision to the other. In the intra-calcaneal methods a short piece of tubing may be inserted at the most dependent part of the wound, or the wound be allowed to gape a little at that point.

Where a heel flap exists, with a pouch beneath, left by the removal of the os calcis—as in Syme's operation—a hole may be made into the pouch through the centre of the flap, and a short length of tubing introduced. This need not be retained for longer than a day.

When the major flap is formed from the heel or sole, it should be remembered that the tissues of those parts are usually tough and unyielding, and that consequently an undue strain comes upon the sutures. These should be deeply inserted, and should not be removed too soon. In a "Syme" they may often be retained for ten days. After their removal it may be necessary to support the flap with strips of strapping.

CHAPTER XXVII.

Osteo-plastic Resection of the Foot.

This operation was designed by Wladimiroff in 1872, and independently by Mickulicz in 1881.

It consists in the removal of the soft parts covering the heel, together with the os calcis and astragalus, and in bringing into contact the sawn surfaces of the tibia and fibula on the one hand, and those of the cuboid and scaphoid on the other. The foot is thus fixed in the position of talipes equinus, and the patient walks upon the balls and phalanges of the toes. The whole of the skin covering the heel is of necessity lost.

The best account of the operation, together with an abstract of nineteen cases, and a full bibliography, is given by Dr. C. Fenger (*Journ. of the Amer. Med. Assoc.*, January 29th, 1887).

Operation.—The foot must be brought well beyond the end of the table, and, the knee having been bent, the foot is turned upon its side. Or the patient may be more conveniently placed in the prone position, the heel being thus directed upwards.

The same *instruments* are required as are used in Pirogoff's operation, with the addition of a periosteal elevator. The following are the steps of this somewhat complex procedure :—

1. A transverse incision is made across the sole of the foot, from the tuberosity of the scaphoid to a point a little behind the base of the fifth metatarsal bone. From the extremities of this cut an incision is carried obliquely upwards and backwards, on either side of the foot, to the bases of the malleoli. The two extremities of the cut are finally connected by a horizontal incision which crosses over the tendo Achillis and completes the wound (Fig. 124, E F G). The incision is carried well down to the bone at all parts. The plantar vessels

are divided at the inner part of the wound, on its plantar aspect.

2. The foot is now flexed to its utmost upon the leg, and while in this position the ankle-joint is freely opened from behind, the tendo Achillis having been of course divided, together with all the ligaments.

Disarticulation at the ankle is effected and the foot still further flexed upon the leg.

3. The soft parts of the dorsum are now separated from the astragalus with an elevator, the instrument travelling from behind forwards. This may be done subperiosteally, so as to avoid any injury to the anterior tibial artery or the extensor tendons.

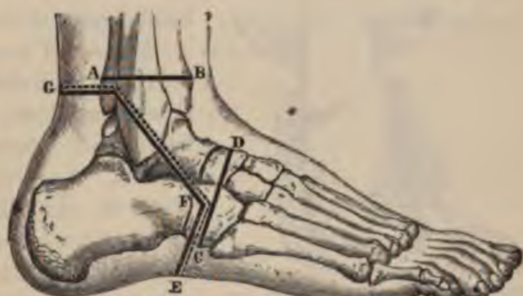

Fig. 124.—OSTEO-PLASTIC RESECTION OF THE FOOT. A B and C D, Saw-cuts: E F G, Skin incisions.

4. The calcaneo - cuboid and astragalo-scaphoid joints are opened from above, and the whole of the heel, together with the os calcis and astragalus, removed.

5. The lower ends of the tibia and fibula are now sawn through horizontally, high enough up to just clear the articular surface of the former (Fig. 124, A B). The joint-surfaces of the scaphoid and cuboid are removed by a vertical saw-cut (Fig. 124, C D).

6. The two cut surfaces of bone are brought together, and are retained in contact by sutures of kangaroo-tendon or of silver wire; the divided ends of the post-tibial nerve are united if possible. The superficial wound is closed and drained, and the foot—now in the position of extreme talipes equinus—is fixed upon a special splint, and secured in position by a plaster-of-Paris dressing.

The soft parts on the dorsum are redundant, and are thrown into folds, but in time they shrink and the surface becomes even. The limb, if adjusted to a splint in the first

instance, should be fixed in plaster of Paris as soon as possible. When the patient begins to walk, a special boot has to be worn (Fig. 125), so as to maintain the parts rigidly in the position of talipes equinus.

It is claimed that osseous union takes place between the cut surfaces of bone. The parts beyond the operation area are nourished by the dorsalis pedis artery and by its anastomoses with the plantar vessels.

Fig. 125.—ASPECT OF LIMB AND INSTRUMENT TO BE WORN AFTER OSTEO-PLASTIC RESECTION OF THE FOOT. (*Brit. Med. Journ.*, May, 1888.)

As a result of the operation the limb is usually a little lengthened.

Comment. — Dr. Fenger has collected nineteen examples of this procedure, in thirteen of which the operation was performed for tubercular caries. Out of the full number two died, some six or eight months after the operation, of general tuberculosis; twelve made a good recovery and walked with more or less ease; in five a failure followed, with the result that in three cases amputation of the leg was called for.

The indications given for the procedure are the following:— Extensive injuries of the heel region; caries of the os calcis and astragalus, with disease of the neighbouring joints; cases of destructive and intractable ulceration of the skin of the heel; some instances of cicatricial contraction of the foot, with inconvenient deformity.

This operation is still on its trial, and has been subjected to much adverse criticism.

The supporters of it probably lay too much stress upon the importance of preserving every possible scrap of the foot. It is a question whether the patients subjected to this operation would walk better than, or even as well as, those who had had the entire foot removed, and had been provided with a good artificial limb. The present operation should not be entertained when the integuments of the heel are sound, because it is certainly

a procedure inferior to Syme's amputation. The process of recovery is very slow; some of the patients were unable to walk well until seven, twelve, or fifteen months had elapsed; others, on the other hand, could walk without the boot.

Moreover, the operation, to be successful, requires good powers for repair, and such powers are not always to be expected in the subjects of tubercular caries. The operation requires a perfectly sound condition of the integuments of the dorsum of the foot—a condition well adapted for a supramalleolar amputation with a long anterior flap.

The operation would seem to be best suited to cases of intractable ulceration of the heel, to cases of gunshot injury, and to some examples of inconvenient deformity

CHAPTER XXVIII.

Amputation of the Leg.

Amputation of the leg was at one time performed almost exclusively at the "place of election," *i.e.*, at a point a hand's-breadth below the line of the knee-joint.

At this point the bones were divided. The selection of this spot was determined by the subsequent needs of the patient. The only prosthetic apparatus he could avail himself of was the "box-leg" or "peg-leg." With this appliance the knee was maintained bent, and the weight of the body was supported upon the tubercle and tuberosities of the tibia. The amputation at the place of election secured this *point d'appui,* and at the same time left no inconveniently long stump projecting backwards from the peg-leg.

The great improvements effected in modern times in artificial limbs, and in the apparatus adopted for cases of amputation, have entirely disturbed the "place of election." The general rule in present operative practice is to remove as little of the limb as possible, it being recognised that the danger to the patient increases—other things being equal—with the height of the amputation. An artificial support can be adapted to the stump that will allow the limb to be retained in its normal position, and will permit the movements of the knee-joint to be still made use of. Even if the amputation be performed at the old place of election, it is by no means necessary that the weight must be borne upon the anterior surface of the tibia. In an amputation at so high a level, an artificial limb can still be employed which will enable the patient to retain the use of the knee-joint.

It comes to pass, therefore, that in amputations of the leg the stump must be able to bear pressure, the bones must be well covered, and the cicatrix should not be terminal. On

this account the circular method is in no way adapted for these operations, and the same remark applies to amputation by lateral flaps of equal size. In both these procedures the resulting cicatrix must be terminal and exposed to pressure.

If in amputating at the old place of election it is determined to use the peg-leg, and to forego the use of the knee, then this question of pressure upon the end of the stump ceases to be of moment, and the circular amputation, or the amputation by equal lateral flaps, may be carried out. It may certainly be said that for amputations below the old place of election the two last-named methods are quite unsuited.

With regard to the *planning of flaps*, it is needless to point out that the soft parts covering the front of the limb are comparatively scanty, and are not particularly well supplied with blood. On the posterior aspect of the limb are extensive muscular layers and two large blood-vessels. On anatomical grounds a posterior flap is to be preferred to an anterior one, inasmuch as it affords a better covering to the bone, is better adapted to resist pressure, and has a fuller and a more evenly distributed blood-supply.

In any case in which the major flap is the posterior one, the posterior tibial nerve should be dissected out, so that it may not be exposed to the otherwise inevitable pressure. This precaution was insisted upon by Hey many years ago.

A large anterior flap must of necessity be composed to some extent of skin alone.

In the upper third of the limb a very excellent flap may be cut from the antero-external aspect of the leg, which has not this disadvantage. This is the large external flap (page 479), which includes in its whole length the anterior tibial artery.

In general terms, it may be said that the cutting of flaps by transfixion in these amputations is to be condemned. This especially applies to the formation of the posterior flap. A flap so cut is apt to be uncertainly fashioned as regards its shape and thickness. The main blood-vessels of the calf can scarcely escape unnecessarily high division. Moreover, the very unequal manner in which the flexor muscles at the back of the leg retract on division renders it desirable that these muscular planes should be divided with precision.

Before sawing the bones, the interosseous membrane should

be carefully divided with a scalpel, so that it may not be grazed by the saw.

In "dissecting up" flaps—*i.e.*, in separating the soft parts they contain from the bones and the interosseous membrane—the forefinger and the handle of the scalpel should be freely used in the place of the cutting blade.

General directions as to the mode of sawing the bone of the leg are given on page 482.

Stumps left after amputation of the leg are very apt to become conical, especially in the lower part of the limb.

The amputations may be dealt with in three regions:—

A. Supra-malleolar amputation.
B. Amputation through the middle of the leg.
C. Amputation at the "place of election."

A.—SUPRA-MALLEOLAR AMPUTATION.

Anatomical Points.—These amputations concern the lower third of the leg. In this region the tibia has become more rounded, and its sharp crest has entirely disappeared. The bone is expanded transversely at the level of the base of the malleolus, while just above that point the shaft is comparatively slender.

The interosseous space is disappearing, and before the ankle is reached the tibia and fibula are in close contact.

The upper band of the anterior annular ligament passes transversely across the limb, above the level of the malleoli, is attached to both the tibia and fibula, and binds down the vertical portion of the extensor tendons. The whole region is surrounded by tendons.

To the lower third of the tibia no muscular fibres are attached; therefore the tibial side of a flap is easily separated. To the corresponding part of the fibula are attached portions of the muscular origin of the extensor communis digitorum, extensor proprius pollicis and peroneus tertius in front, of the peroneus brevis externally, and of the flexor longus pollicis behind.

When the lower third of the limb is reached, the gastrocnemius and soleus have joined, while the muscular fibres of the latter muscle are rapidly disappearing into the tendon. The other tendons about this segment of the leg, viz., those of the tibialis anticus, tibialis posticus, peroneus longus,

and flexor longus digitorum, are still accompanied by muscular fibre. The tendons most free of muscular tissue are those of the tibialis anticus and peroneus longus. The largest muscular mass near the ankle belongs to the flexor longus pollicis.

The anterior tibial artery lies in front of the tibia, between the tibialis anticus and extensor communis digitorum, and is crossed obliquely by the extensor proprius pollicis. The nerve is placed to its outer side. The peroneal artery lies close to the inner border of the fibula, under cover of the flexor longus pollicis, and just above the malleolus breaks up into the anterior and posterior peroneal vessels. The posterior tibial artery is comparatively superficial at the lower third of the leg; it lies behind the inner part of the tibia, and skirts the outer border of the flexor longus digitorum muscle. To its outer side lies the posterior tibial nerve.

The long saphenous vein passes in front of the inner malleolus, while behind the external malleolus runs the short saphenous vein.

Methods.—The following methods of operating will be described:—

1. Oblique elliptical incision (Guyon's operation).
2. Modified circular.
3. Oblique elliptical incision (Duval's operation).
4. Large posterior flap.
5. Teale's amputation.

Instruments.—A small amputation-knife with a blade of about five inches; a stout, somewhat narrow, knife, with a blade four inches long, a narrow but rounded point, and a large, strong handle (this would be a modified resection knife, and is required for Guyon's operation; it may also be used to separate the anterior or posterior flap from the bones in the other amputations); a scalpel, an amputating-saw, retractors, pressure forceps, artery and dissecting forceps, scissors, etc.

Position.—The patient lies on the back, with the foot and lower part of the leg projecting well beyond the end of the table. The surgeon should stand to the outer side of the right limb, and to the inner side of the left. In performing Guyon's amputation, he may more conveniently take up his position at the foot of the table.

One assistant stands or sits facing the end of the table.

He holds the foot, and manipulates it when required, during the operation. A second assistant stands facing the surgeon, and attends to the sponging, etc.

1. **Amputation by Oblique Elliptical Incision** (*Guyon's Operation*).—This operation a little resembles Syme's amputation. It allows the terminal part of the stump to be covered by the tissues of the back of the heel, and involves a low division of the bones. It can rightly be termed a supra-malleolar amputation, and the medullary canals of the bones are not opened by the saw.

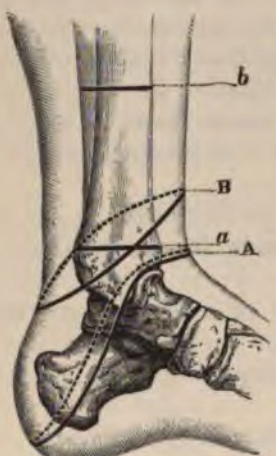

Fig. 126.—A, Guyon's supra-malleolar amputation: (*a*), saw-line for that operation; B, Duval's supra-malleolar amputation; (*b*) saw-line for this operation.

The incision commences in front, at a point just opposite the line of the ankle-joint, and ends behind, over the summit of the curve of the heel.

Between these points the incision sweeps in a slightly curved manner from above downwards across the ankle. The cut on the inner side just skirts the malleolus; on the outer side it passes a little in front of the corresponding process (Fig. 126, A).

In making the skin incision the surgeon holds the foot in his left hand, and manipulates it himself.

In dealing with the right foot it is convenient to turn the foot inwards, and to commence the incision at the heel and on the outer side.

The knife then traverses the external side of the limb, and reaches the front of the ankle. The foot being now turned outwards, the incision is carried back along the inner side of the foot to the heel again. On the left side, the foot having been turned inwards, the incision may be commenced in front, and be carried back to the heel along the outer aspect of the limb. When the foot has been turned outwards, the ellipse is completed by drawing the knife from the heel to the starting-point across the inner side of the ankle.

The first incision involves merely the skin and the sub-

cutaneous tissues. The surgeon then proceeds to dissect up the posterior or heel flap. This must include all the soft parts down to the bone. An exception may be made of the peronei tendons behind the external malleolus. They need not be disturbed, and should not be divided until a level above the ankle-joint has been reached. Great care must be taken of the vessels on the inner side of the os calcis. The tendo Achillis is cut, and the soft parts are cleared away from the bones of the leg up to a point about two inches above the tips of the malleoli. It is convenient to sit in order to dissect up the posterior flap.

Fig. 127. — STUMP LEFT BY GUYON'S SUPRA-MALLEOLAR AMPUTATION. (*After Farabeuf.*)

The foot should now be extended, and the anterior incision carried well down to the bone, care being taken to avoid opening the ankle-joint. The soft parts on the front of the leg are dissected up to the level named.

Retractors having been adjusted, the bones are divided horizontally well above the bases of the malleoli.

The posterior tibial nerve should be dissected out and removed.

Hæmorrhage.—The anterior tibial artery is divided near the anterior border of the tibia. The posterior tibial vessel is cut at the inner side of the heel flap, and the termination of the peroneal at the outer side.

In the soft parts in front of the outer malleolus the anterior peroneal is divided.

Comment.—This amputation would of course not be performed should Syme's operation be possible. The stump, when the margins of the wound have been united by suture, looks a little clumsy.

The cicatrix, however, is transverse, is well on the anterior aspect of the limb, and is removed from the line of pressure. A good stump is ultimately provided, one valuable feature of which consists in the covering furnished by the integuments of the heel (Fig. 127).

The amputation permits of a very low division of the bones.

2. **Modified Circular Amputation.**—This method has been recommended in this region, and appears to have been frequently practised by French surgeons. Such an amputation is that known as Lenoir's (Fig. 131, A). A circular incision is made into the soft parts just above the malleoli, and about 1½ inch, or 4 c.m., below the point at which the bones are to be sawn. This is joined by a vertical cut, in the middle of the leg, which is carried up to the level of the saw-line along to the inner side of the tibial crest.

The anterior skin flaps—*i.e.,* the flaps (such as they are) on either side of the vertical wound—are dissected up as far as possible. The circular incision is not disturbed after the integuments have been well freed. All the soft parts down to the bone are now divided by one sweep of the knife, held very obliquely.

The operation is easy to perform, but is not to be recommended. The skin covering of the bones is a great source of weakness; the cicatrix occupies the end of the limb, and is exposed to pressure; and a conical stump can hardly be avoided.

Dupuytren employed a circular incision just above the malleoli, so inclined that the posterior part of the circle touched the insertion of the tendo Achillis, while the anterior segment crossed the limb a little above the ankle-joint.

Two vertical incisions were then made, one on the front and the other on the back of the limb, and both in the median line. In this manner two lateral flaps were formed.

The objections urged against the last operation apply equally to this procedure.

3. **Amputation by Oblique Elliptical Incision** (*Marcellin Duval's Operation*).—In this operation the bone is divided much higher up than in Guyon's amputation. An oblique elliptical incision is made around the limb above the malleoli.

The incision is thus planned:—The point at which the bones are to be divided having been determined upon, the lower or posterior extremity of the ellipse should reach a distance below that point equal to not less than the antero-posterior diameter of the limb at the level of the saw-cut. The higher, or anterior, extremity of the ellipse should be no less

distance below the proposed saw-cut than that equal to half the antero-posterior diameter (Fig. 126, B).

In effecting these measurements allowance must be made for retraction of the skin. Thus—as Farabeuf says—if the antero-posterior diameter at the level of the saw-cut be 8 c.m., then the posterior end of the incision should reach a point 12 c.m. below that level, while the anterior extremity of the skin-cut should be 6 c.m. below the same. The incision is inclined at about 45 degrees.

The *position* of the surgeon has been already indicated. An assistant manipulates the foot. On both the right and the left limb the wound can be more conveniently commenced at the posterior aspect of the leg.

The first incision includes the skin only. The skin is well separated, and is allowed to retract. The knife—kept close to the margin of the retracted skin—is now made to traverse all the soft parts down to the bone. The tendo Achillis is cut early. The tissues, on both the anterior and posterior aspects of the limb, are dissected up to a little beyond the level of the proposed saw-cut.

This dissection is by no means easy, especially on the peroneal side of the limb. The bones must be well bared. In dissecting up the posterior tissues the surgeon may sit and have the leg well raised in front of him. After the bones have been divided the posterior tibial nerve is dissected out. Some surgeons advise that the tendo Achillis be connected, by deep sutures, with the divided ends of the anterior muscles.

Hæmorrhage.—The anterior tibial artery is divided in front of the tibia; the posterior tibial behind the base of the inner malleolus; the posterior peroneal behind the outer malleolus, and the anterior peroneal in the posterior flap opposite the lower end of the interosseous space.

Comment.—This operation would be very difficult should there be any matting together of the soft parts from chronic disease.

The stump looks a little clumsy at first. The cicatrix is transverse, and is placed upon the anterior aspect of the stump (Fig. 128). It is nearer the extremity of the stump than is the scar in Guyon's amputation.

4. **Amputation by a Large Posterior Flap.**—This opera-

flap is so marked out that in its length, as well as in its breadth, it shall be equal to one-half the circumference.

The posterior flap should be one-fourth the length of the anterior flap, and will include the remaining half of the circumference of the limb (Fig. 129).

The lateral incisions follow the margins of the tibia and

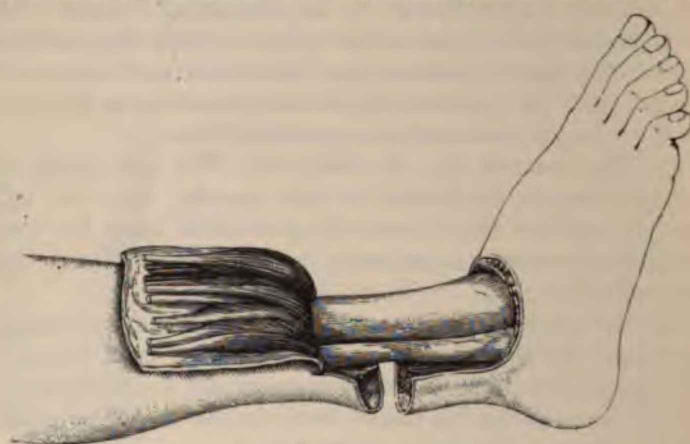

Fig. 129.—TEALE'S AMPUTATION OF THE LEG.

fibula. The limits of the greater flap may be conveniently marked out upon the skin with ink.

The *position* of the surgeon and his assistants has been already indicated.

The anterior flap may be commenced on the inner side of the limb on the right side, and on the outer aspect on the left side. The two lateral incisions should be made by cutting from above downwards. It should be remembered that the anterior flap is rectangular, and of the same size all the way down.

The incision marking out the great flap should at first concern the skin only. The incision is then deepened down to the bones. The foot should be extended while the tendons at the end of the flap are being divided.

The anterior flap should contain all the soft parts on the front of the limb. These should be carefully dissected up from the bones and the interosseous membrane. The flap contains the anterior tibial artery in its whole length.

down to the fibula, and the wound is deepened, so far as it extends, by separating the muscles from that bone. In this manner two deep lateral slits or gaps (*fentes*) are made down to the bones through the whole thickness of the posterior flap.

The thumb having been thrust into one of these gaps, and the forefinger into the other, the soft parts at the back of the limb can then be pinched up by the surgeon's left hand. The foot is maintained in the flexed position, while the posterior flap is completed by cutting from without inwards (as shown in Fig. 132). The posterior flap so fashioned leaves the bones and the interosseous membrane practically free.

(3) The anterior flap is now cut. The soft parts are divided down to the bones as soon as the skin has fully retracted, and are then dissected up so as to leave the bones and the interosseous membrane on this aspect of the limb practically bare also.

(4) Retractors having been adjusted and the interosseous membrane divided, the tibia and fibula are sawn through; the posterior tibial nerve is dissected out and removed.

Deep sutures may be passed between the muscular masses upon the front and back of the limb.

Hæmorrhage.—The anterior tibial artery is cut in the anterior flap, in front of the interosseous space. The posterior tibial and peroneal vessels are divided posteriorly; the former about the middle of the flap, and the latter in a line with the fibula. The internal saphenous vein may possibly be cut in making the internal vertical incision. It usually, however, lies wholly in the posterior flap, at the lower and inner angle of which it is found divided.

Comment.—The stump has prominent "ears," and at first may look a little clumsy. It generally, however, turns out admirably. The bones are well covered by the thick posterior flap, and the cicatrix, which is transverse, is well removed from the line of pressure.

5. **Teale's Amputation by a Large Anterior Flap.**—The lower third of the leg is considered to be a particularly favourable position for the practice of Teale's amputation.

The general plan of the operation has been already described (page 296). The circumference of the limb having been taken at the level of the future saw-line, the anterior

flap is so marked out that in its length, as well as in its breadth, it shall be equal to one-half the circumference.

The posterior flap should be one-fourth the length of the anterior flap, and will include the remaining half of the circumference of the limb (Fig. 129).

The lateral incisions follow the margins of the tibia and

Fig. 129.—TEALE'S AMPUTATION OF THE LEG.

fibula. The limits of the greater flap may be conveniently marked out upon the skin with ink.

The *position* of the surgeon and his assistants has been already indicated.

The anterior flap may be commenced on the inner side of the limb on the right side, and on the outer aspect on the left side. The two lateral incisions should be made by cutting from above downwards. It should be remembered that the anterior flap is rectangular, and of the same size all the way down.

The incision marking out the great flap should at first concern the skin only. The incision is then deepened down to the bones. The foot should be extended while the tendons at the end of the flap are being divided.

The anterior flap should contain all the soft parts on the front of the limb. These should be carefully dissected up from the bones and the interosseous membrane. The flap contains the anterior tibial artery in its whole length.

The posterior flap may be completed by a simple vigorous transverse cut across the back of the limb from the skin to the bones.

The foot should be flexed during this manœuvre. The flaps having been retracted to a little beyond the saw-line, the retractors are applied, the interosseous membrane is divided, and the bones are sawn through.

When the wound has been closed by sutures, the stump has the appearance shown in Fig. 130.

Hæmorrhage.—The anterior tibial vessels are divided at the free lower end of the anterior flap, and at about its middle. The posterior tibial artery is found cut upon the face of the posterior flap and towards its inner side, the vessel lying between the margins of the flexor longus digitorum and flexor longus pollicis.

Fig. 130.—STUMP LEFT AFTER TEALE'S AMPUTATION OF THE LEG.

The peroneal vessels are divided on the outer part of this flap, close to the fibula, and under cover of the flexor longus pollicis.

The long saphenous vein will be found in the anterior flap, the short saphenous in the posterior flap.

Comment.—Inasmuch as the leg narrows towards the ankle, it is easy, by following the general lines of the limb, to make the anterior flap too narrow below.

It is claimed for this amputation that the bones are covered by a flap which does not contain too much muscular tissue, and which possesses an artery in its entire length. It is also urged that the cicatrix is placed at the back of the stump, and is not exposed to pressure.

The operation has not been received with so much favour in other countries as it undoubtedly possesses in England.

The main bone to be covered at the end of the stump is the tibia. The anterior flap affords this bone in large part a covering of skin only, and the integuments on the front of the leg are usually quite thin. The anterior flap, moreover,

is of very unequal thickness, containing skin only at its inner part, and a substantial mass of muscle at its outer side. It has been pointed out that a portion of the anterior flap may be cut from the dorsum of the foot; but the tissues of that part are ill adapted to form the free end of a principal flap. The skin there is very thin, the subcutaneous tissue is scanty, and the soft parts beneath are represented almost exclusively by tendons. Teale's amputation makes a great demand upon the structures on the anterior aspect of the limb, and involves a comparatively high division of the bones.

Of the four operations above described, it may be said in general terms that Guyon's amputation is the best when a low division of the bones is possible, and that the most suitable mode of amputating the leg in its lower third is by means of the long posterior flap.

Should the tissues at the posterior aspect of the limb be much damaged, Teale's operation may be conveniently carried out.

B.—AMPUTATION THROUGH THE MIDDLE OF THE LEG.

Anatomical Points.—At the middle of the leg the limb is very muscular, the mass of muscles in the calf being considerable. The main muscle in front of the interosseous membrane at this level is the tibialis anticus. The extensor communis digitorum is of fair size, the extensor proprius pollicis is as yet small. All these muscles are attached to the bones. The anterior tibial artery lies in front of the interosseous membrane, midway between the two bones, and is very deeply placed. At the back of the limb the main muscular mass belongs to the soleus. The muscle is free except at its inner side, where it is still attached to the internal border of the tibia. It is capable therefore of some retraction when divided. The plantaris tendon is free. The gastrocnemius at this level is still muscular. On section its bulk is seen to be scarcely equal to a third of the bulk of the soleus. It is quite free from bony attachment, and can therefore retract readily when divided. The freedom of the gastrocnemius and soleus muscles is of primary importance in the execution of Henry Lee's operation.

The remaining muscles at the back of the limb are all

attached to the bones, and are not therefore capable of retraction. Of these, the tibialis posticus is the largest; the flexor longus digitorum is of fair size; while the flexor longus pollicis is as yet small.

The peroneal artery lies close to the fibula, under cover of the last-named muscle. The posterior tibial vessels lie in the groove between the tibialis posticus and the flexor longus digitorum. At the outer side of the limb are the two peronei muscles, both attached to the fibula. The peroneus longus at this level is large, the peroneus brevis very small.

With regard to the operations which may be performed at the middle of the leg, reasons have been already given for condemning the circular amputation and the cutting of a posterior flap by transfixion (page 461).

Teale's operation is sometimes advised in this position. The objections which have been urged against that amputation in the lower third of the leg apply equally to this section of the limb. The anterior flap is of considerable length, and the bones have to be divided at an unnecessarily high level. The operation may be carried out when the soft parts at the back of the limb have been extensively destroyed.

The two procedures best adapted for this region are the following:—

1. **Amputation by a Large Posterior Flap** (*Hey's Operation*).

Instruments.—An amputating-knife with a blade about five inches in length; a stout scalpel; an amputating-saw; retractors (the linen retractor used to protect the parts during the sawing of the bones may have three tails, the central and narrower slip being passed through the interosseous space); pressure forceps; artery and dissecting forceps; a periosteal elevator; scissors, etc.

Position.—The patient lies upon the back, with the leg and knee beyond the end of the table. In dealing with the right limb, the surgeon stands to the outer side of the leg; in dealing with the left limb, to the inner side. One assistant stands or sits facing the end of the table. He holds the foot and leg, and manipulates it during the operation. A second assistant stands facing the surgeon and to the left of the patient, and attends to the sponging, etc.

Operation.—Hey's operation is described in his "Practical Observations" (3rd edition, 1814, page 526). The procedure here detailed is a slight modification of Hey's method. Hey cut the posterior flap by transfixion, and made a slightly shorter anterior flap.

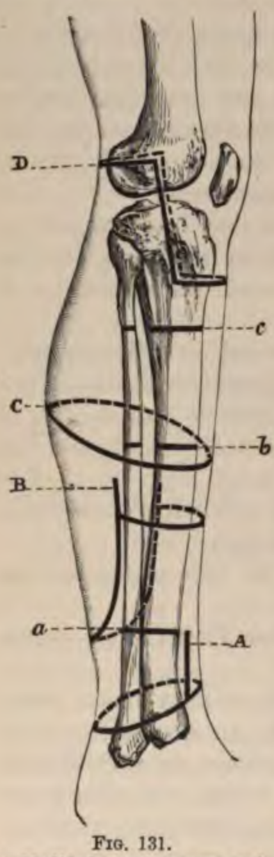

FIG. 131.

A, Modified circular supra-malleolar amputation: (a) saw-line of same: B, Hey's amputation: (b) saw-line of same; C, Circular amputation at "the place of election": (c) saw-line of same; D, Gritti's operation.

The circumference of the limb at the saw-line having been noted, the posterior flap is so made that its length and breadth are equal to a third of that measurement—*i.e.*, are equal to the diameter of the limb.

The anterior flap is about a third of the length of the posterior one. The large posterior flap is U-shaped. The main incisions are commenced about one inch below the point at which the bones are divided. The inner limb of the U of the posterior flap is just behind the internal border of the tibia, while the outer limb of the U runs posterior to the peronei muscles (Fig. 131, B). These muscles are consequently found divided in the anterior flap.

(1) The operation is commenced by cutting the large flap.

On the right side the limb is turned upon its outer surface (*i.e.*, with that surface looking downwards), the knee is flexed, and the inner vertical incision is made from above downwards. The inner segment of the bend of the U is then completed. The leg is now turned upon its inner side, and the outer vertical incision is made by cutting from above downwards. In finishing it, the bend of the U, the terminal part of the flap, is completed (Fig. 131, B). On the left leg the limb may be first turned upon its inner side (*i.e.*, with that surface

looking downwards), and the operation be commenced by cutting the outer vertical incision.

The incisions thus made concern the skin only, and the integuments are well freed along all parts of the cut.

(2) The leg is now flexed upon the thigh, and the knee turned outwards so as to expose the calf. When in this position, and while the foot is flexed, the gastrocnemius muscle is picked up between the fingers and thumb and is divided transversely at the level of the retracted skin.

(3) Two short, deep, vertical incisions are now made from above downwards through the soft parts at either margin of the flap. These incisions extend to the bone: the inner direct to the tibia, the outer to the fibula behind the peronei muscles.

Into the gaps thus made the thumb and fingers of the left hand are inserted, and the muscles of the calf, being firmly grasped, are lifted up from the bones. (*See* Fig. 132.)

The muscles are now carefully separated from the bones along these two short lateral incisions with a stout scalpel until the middle of the flap is entirely free, and the thumb and forefinger can be made to meet between the deep muscles and the bones. These muscles and the vessels they carry with them are finally divided at their lower parts by a vigorous transverse cut. To effect this, the amputating-knife is introduced between the separated muscles and the bones, and is made to cut from within outwards. The posterior flap is now quite free below, and the soft parts above are cleared away from the tibia and fibula and intervening membrane until the level of the saw-cut is reached.

(4) The anterior flap is made by passing the knife in a curved manner across the face of the limb. The incision at first involves the skin only. When retraction has taken place, the muscles are cleanly divided down to the bones. These muscles are then dissected up as far as the level of the future saw-cut, the interosseous membrane being thus bared in front as well as behind.

(5) Retractors having been applied, and the interosseous membrane divided transversely, the bones are sawn through. The periosteum may be separated from the lower end of the tibia.

The prominent projection of the anterior border of the tibia should be removed with the saw in the manner described on page 483. (*See* Fig. 137.)

The posterior tibial nerve is dissected out and removed.

Hæmorrhage.—The anterior tibial artery is divided at the free end of the anterior flap, the posterior tibial and peroneal vessels at the free margin of the posterior flap. The position of these vessels has been already indicated.

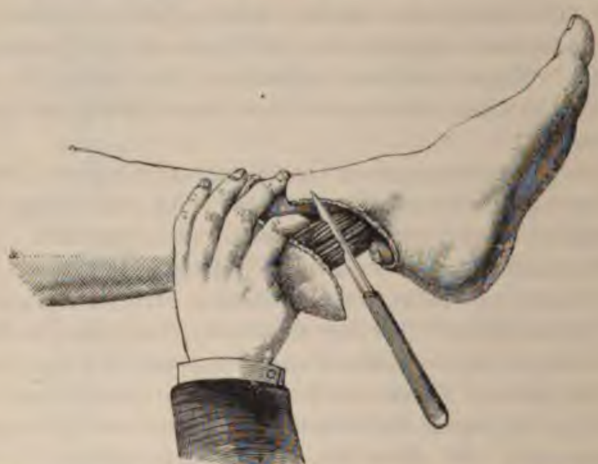

Fig. 132.—MODE OF DIVIDING THE TISSUES IN THE AMPUTATION BY A LARGE POSTERIOR FLAP.

2. **Amputation by Large Posterior Flap** (*Henry Lee's Operation*).

An account of this operation is given in the *Medico-Chirurgical Transactions* (vol. xlviii., page 195).

The instruments required, and the position of the patient and operator, are the same as in the previous amputation.

The same order may be observed in making the incisions.

The flaps are measured and fashioned, so far as the skin incisions are concerned, precisely upon the lines of Teale's operation, with the difference that the main flap is upon the posterior instead of upon the anterior surface of the limb. The principal flap, moreover, instead of containing all the soft parts covering the bones, carries with it only the superficial

flexor muscles of the calf. Both flaps are rectangular. The anterior flap is one-fourth the length of its fellow (Fig. 143, B). The relation of the incisions to the saw-line is the same as in Teale's method. Both flaps are marked out with the knife, the incisions involving at first the integuments only. The anterior flap is the first to be completed. The subsequent steps are thus described by Mr. Lee:—

"When the skin has become somewhat retracted by its natural elasticity, an incision is carried through the parts in front of the tibia, interosseous membrane, and fibula. The whole of the parts thus divided are separated close to the periosteum and interosseous membrane, and are reflected upwards to a level with the upper extremities of the first longitudinal incisions.

"The deeper structures at the back of the leg are then freely divided in the situation of the lower transverse incision. The conjoined gastrocnemius and soleus muscles are separated from the subjacent parts, and are reflected as high as the anterior flap. This part of the operation is performed with the greatest facility on account of the loose attachments of these muscles, especially at the lower part of the leg.

"The deeper layer of muscles, together with the large vessels and nerves, is divided as high as the incisions will permit, and the bones sawn through in the same situation."

The prominent projection of the anterior border of the tibia should be removed with the saw. (*See* page 483; Fig. 137.)

The posterior tibial nerve should be dissected out.

The position of the three principal arteries divided has been already mentioned.

Comment.—Both of these operations are excellent. The bones are well covered; the cicatrix is transverse, is upon the anterior aspect of the stump, and is well removed from pressure.

The posterior flap in Hey's amputation is shorter than in Lee's operation. In the former its length is equal to a third of the circumference of the limb; in the latter, to one-half. Provided that the conditions are the same, it will be seen that the second operation involves a greater sacrifice of parts than the first; in other words, Hey's amputation can be performed lower down.

The procedure advised by Lee is well adapted for very muscular limbs, and for cases where the deep muscles of the calf have become matted together or damaged by disease or injury.

Hey's operation is, on the other hand, well suited to the majority of cases, and especially to limbs of moderate or scanty muscular development.

Of the two operations, Lee's is undoubtedly the more easy to perform.

C.—AMPUTATION AT THE "PLACE OF ELECTION."

Anatomical Points.—The term "place of election" refers to the spot at which the bones are divided. This point is about a hand's-breadth below the knee-joint, and is about, or a little above, the great nutrient foramen of the tibia. The tibia is here still of good size, the cancellous tissue is considerable, but the medullary canal has commenced.

The skin covering the upper third of the leg is a little coarse, is not very mobile, and does not retract so extensively when divided as it does lower down in the limb.

A transverse section of the leg at the "place of election" shows that the main muscular masses on the antero-external aspect belong to the tibialis anticus and the peroneus longus. The extensor communis digitorum is still a very small muscle. The peroneus brevis and the extensor longus pollicis do not reach the saw-line, but are found in an external flap.

At the back of the limb the gastrocnemius forms a very large mass of muscle—so large as to be nearly equal to the rest of the muscular tissue which lies behind the bones and interosseous membrane.

The soleus is—at this level—divided at about its largest part. The tibialis posticus is of fair size; the flexor longus digitorum appears as a mere muscular fragment. The flexor longus pollicis lies below the level of the "place of election." The lowest fibres of the popliteus are divided in the section as they adhere to the posterior surface of the tibia.

In separating or "dissecting up" a flap, it must be observed that the only muscles free are the gastrocnemius and plantaris. All the others are attached to the bones or interosseous membrane.

The anterior tibial artery at the present level lies deeply upon the face of the interosseous membrane, and close to the fibula. The anterior tibial nerve is to its outer side.

The posterior tibial and peroneal arteries are found lying upon the tibialis posticus and occupying the same level, the latter vessel having but just arisen from the trunk. These vessels are located about midway between the two bones.

The posterior tibial nerve is very close to the artery of the same name, but is placed just behind it and to its inner side.

The following are the *methods* described :—

1. Large external flap (Farabeuf's operation).
2. Circular method.
3. Equal lateral flaps.
4. Large posterior flap.

1. Amputation by Large External Flap (*Farabeuf's Operation*).—An amputation in this part of the leg by an external flap has been devised and carried out by Sédillot and others.

Farabeuf has, however, so far modified the operation that he has practically designed a new procedure. He has pointed out the importance of preserving the anterior tibial artery in the whole length of the external flap, and has shown that if this flap be cut by transfixion the vessel cannot escape damage.

The present method may claim to be a very substantial improvement upon previous operations, and to form a valuable addition to the resources of the surgeon.

Instruments.—An amputating-knife with a blade from five to six inches in length. A stout scalpel. An amputating-saw. A periosteal elevator. Retractors. Six pressure forceps. Artery and dissecting forceps. Scissors, etc.

Position.—The patient lies upon the back, and is so placed that the middle of the thigh rests upon the edge of the table. The sound limb is secured out of the range of the operation.

In operating upon the right leg, the surgeon stands throughout on the outer side of the limb. In amputating the left leg, he should stand at the end of the limb, and a little to the outer side of it, while making the preliminary skin

incisions. While dissecting up the flap and completing the operation, he should stand to the inner side of the limb.

One assistant is placed at the end of the limb, to manipulate the foot and leg. The second assistant stands upon the opposite side of the limb to the surgeon, whom he faces.

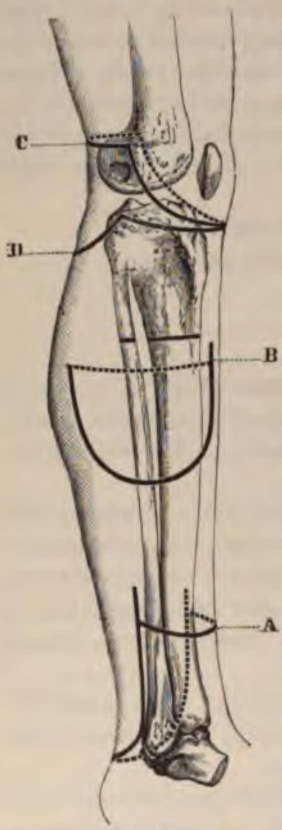

FIG. 133.

A, Amputation of lower part of leg by long posterior flap; B, Amputation at "the place of election" by large external flap (Farabeuf's operation); C, Carden's amputation; D, Lister's modification of the same.

Operation.—The external flap is **U**-shaped. Its length is equal to that of the diameter of the limb at the level of the future saw-line—*i.e.*, is equivalent to one-third of the circumference of the leg at the same level (Fig. 133, B).

The anterior limb of the **U** is commenced opposite to the saw-line, and in passing down the leg runs parallel with and just to the inner side of the anterior border of the tibia.

The posterior limb of the **U** follows a line on the back of the calf diametrically opposite to the anterior limb. The posterior incision ends, however, above, at a point about $1\frac{1}{2}$ inch below the commencement of the anterior limb of the **U**.

1. The operation is commenced by marking out the external flap by a skin incision.

In the case of both the right and the left legs, the knee should be flexed and the limb turned upon its inner side—*i.e.*, so turned that its outer aspect is well exposed to the surgeon. The position of the operator while making the skin incisions has been alluded to. On the right side the incision may be commenced in front, and may be completed in one sweep, the anterior wound being thus made from above downwards and the posterior from below upwards. In the case of

the left limb, both of the vertical incisions can be more conveniently made by cutting from above downwards, and can be subsequently joined by the terminal curved incision.

2. The next step in the operation is to free the skin along the whole length of the incision, so that it may retract. The integuments are merely freed, not dissected up.

3. The limb being turned outwards, the knife is passed across the inner side of the leg, from the upper end of the posterior incision to a point on the anterior cut about 1½ inch below its commencement (Fig. 133, B). This incision

Fig. 134.—MODE OF CUTTING THE FLAP IN THE AMPUTATION AT "THE PLACE OF ELECTION" BY A LARGE EXTERNAL FLAP. (*Farabeuf.*)

is slightly curved, and involves the skin only. The integuments are lightly freed along the line of the incision.

4. The limb being again turned with its inner surface downwards, the operator proceeds to dissect up the great flap, which should contain all the soft parts down to the bones.

The flap is separated along the anterior limb of the U incision by cutting from above downwards down to the bone along the outer side of the anterior border of the tibia. The fingers of the left hand are thrust into the gap so made, and the tibialis anticus is separated from the bone. When the muscle is sufficiently separated, it is cut obliquely from above downwards and outwards, so that the section of the muscle will be thin when the margin of the skin is reached (Fig. 134).

The whole of the soft parts involved in the external flap

are dissected up from the bones and interosseous membrane. In effecting this the finger and the handle of a scalpel are used more freely than the knife. The muscles should be cut obliquely at their lower extremities, so that the section of muscle close to the free margin of the skin—*i.e.*, at the bend of the U—shall be quite thin. The anterior tibial artery is divided at the free end of the flap in making one of these oblique sections of the muscles (Fig. 138).

In dissecting up the soft parts, great care must be taken not to dissect the flap up too far. If this be done, it is possible

Fig. 135.—METHOD OF SAWING THE TIBIA.

Fig. 136.—METHOD OF SAWING THE BONES OF THE LEG.

Fig. 137.—METHOD OF SAWING THE BONES OF THE LEG.

to reach the spot where the anterior tibial artery is piercing the interosseous membrane, and to actually divide the vessel at that spot.

The future of the operation depends upon the integrity of this artery.

5. The soft parts included in the small inner flap may now be cut by transfixion at the level of the retracted skin. The muscular tissue so divided must be in the next place separated from the bones up to the level of the saw-line. The bones and interosseous membrane should be bared. The retractors are now applied and the bones sawn through.

6. The manner in which *the bones are sawn* is of some importance, especially as the prominent anterior border of the tibia is apt to project into the anterior wound when the flaps have been adjusted. The remarks now to be made apply to all amputations in this region.

The interosseous membrane having been incised, the periosteum covering the tibia is divided by a circular cut. This circular cut is joined from above by two lateral vertical incisions through the investing membrane. The two flaps—anterior and posterior—of periosteum thus marked out should be separated from the bone by an elevator. If preferred, these flaps may be dissected up from the bone with the deepest layers of muscle; or, on the other hand, the periosteum on the posterior surface of the tibia may be ignored, and only the anterior segment preserved. Some surgeons strip up the periosteum from the fibula also.

The periosteum is retracted to a point just above the saw-line. The surgeon stands in the same position—*i.e.*, to the outer side of the right leg and to the inner side of the left—and divides the fibula first. The limb is still so placed that the external surface is uppermost. In sawing the left fibula, the point of the saw is directed downwards, towards the floor. In dividing the right bone, the point of the instrument is directed upwards, towards the ceiling. The fibula should be divided about 1 c.m. above the tibia, and the saw should pass obliquely from above downwards and inwards (Fig. 136). The saw is now entered upon the inner surface of the tibia, above the level at which the bone is to be divided. The instrument is made to cut downwards and outwards for a certain distance (Fig. 135, A). The transverse saw-cut is now made from before backwards (Fig. 135, B), with the result that the whole bone is divided, the piece marked out by the first saw-incision drops off, and the tibia presents a sloping surface on its inner side (Fig. 136).

This method of dividing the bones is adapted to the amputations by external flap or by two lateral flaps.

In the case of amputation by antero-posterior flaps or by the circular method, the fibula may be cut at the same level as the tibia, and the anterior margin of the tibia should then be removed by a sloping saw-cut, the instrument being applied in the manner just detailed (Figs. 135 and 137).

The periosteal flap or flaps having been adjusted over the divided bone, and any deep sutures having been inserted, the operation is completed by closing the surface wound.

Hæmorrhage.—The anterior tibial artery is divided at the

free end of the external flap. The posterior tibial and peroneal vessels are cut close together and lie on the same plane upon the face of the inner flap. (*See* page 479 and Fig. 138.)

Several muscular branches will require ligature, notably the sural arteries connected with the gastrocnemius muscle, and the large branch from the posterior tibial artery to the soleus. The nutrient artery of the tibia will be divided at or about its entrance into the bone.

Comment.—An excellent stump results from this operation. The cicatrix comes upon its inner side and is well removed from pressure. The bones are admirably covered, and, if the operation be carefully carried out, the vitality of the great flap is ensured (Fig. 139).

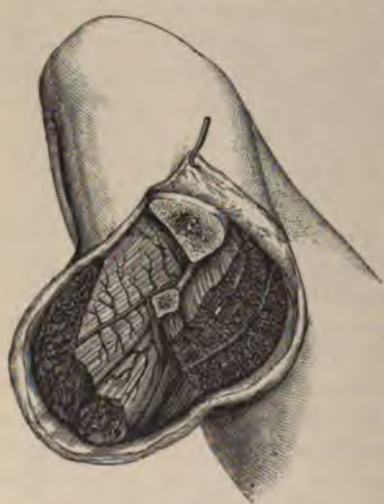

Fig. 138.—APPEARANCE OF THE STUMP AFTER THE AMPUTATION OF THE LEG AT "THE PLACE OF ELECTION" BY A LARGE EXTERNAL FLAP. (*Farabeuf.*)

I believe this to be the best operation for this segment of the leg. I have performed it in several cases which were by no means well adapted for recovery from any amputation, and have been exceedingly pleased with the results. These cases were examples of amputation of the limb in aged and broken-down men for intractable ulcers of the lower part of the leg.

The stump that results is sufficiently long to allow of such an artificial leg being worn as will still permit the movements of the knee to be executed.

In selecting a method of amputation at this level, considerable weight must attach to the intention of the surgeon with regard to the artificial support that is to be worn.

If the use of the knee-joint is to be retained, then a stump must be fashioned that can bear pressure upon its extremity.

If, on the other hand, the knee-joint is to be kept permanently flexed, and the weight of the body is to be borne

upon the tuberosity and tubercle of the bent tibia, then the coverings of the stump and the position of the cicatrix are matters of comparatively little moment.

The operation next described involves a terminal cicatrix, and a not too well-covered tibia. It is, however, a convenient and sound procedure if the patient is to wear a peg-leg or box-leg, and is to surrender the use of the knee-joint.

Fig. 139.—STUMP RESULTING FROM AMPUTATION OF THE LEG AT "THE PLACE OF ELECTION" BY A LARGE EXTERNAL FLAP. (*Farabeuf.*)

2. **Amputation by the Circular Method.**—The same instruments are required as in the last operation. The position of the surgeon and his assistants is the same, with the exception that the operator, in dealing with the left limb, stands throughout on the inner side of the leg.

The circular skin-incision should be made at a distance below the saw-line equal to one-half of the diameter of the limb at that line (Fig. 131, C). This applies to the position of the incision when retraction of the skin has been allowed for.

For example: suppose the circumference of the limb at the saw-line to be 15 inches, the diameter of the limb will be represented by 5 inches, and the half-diameter by 2½ inches, or about 6 c.m. Retraction of the skin in this part of the limb is not considerable. To allow for it, the circular mark in the skin might be commenced about 3½ inches, or 9 c.m., below the saw-line.

The posterior segment of the circular incision should be a little higher than the anterior segment (Fig. 131, C). The tissues at the back of the leg—notably the superficial flexors—retract more readily than do the soft parts upon the front of the limb. If the circular incision be quite horizontal, too much skin will be found in what may be termed the posterior flap.

Operation.—1. The limb being extended, the circular skin-incision is made, the assistant manipulating the limb the while. The skin is lightly freed all round along the line of the incision.

2. The skin at the anterior aspect of the limb is separated

from the soft parts, and is turned up as a cuff until the soft parts are exposed at the same level all round the limb. At the sides and at the posterior aspect of the leg the skin—which has here merely undergone its natural retraction—is not disturbed.

3. The knee is now flexed, and the leg turned outwards—*i.e.*, with its outer surface directed downwards. The calf being well exposed, the gastrocnemius muscle is separated from the deep flexors with the fingers, and is divided transversely at the level of the retracted skin.

4. The integuments all round are now retracted as high as possible, the gastrocnemius muscle being separated up with the skin at the posterior part of the leg.

This retraction and separation of the skin should not reach so high as the future saw-line.

5. The soft parts are now divided transversely a little below the saw-section. The division is commenced in front, and the limb is rotated from side to side or elevated by the assistant as the surgeon requires. These soft parts are now separated all round from the bones and the interosseous membrane, and the separation is carried to a point a little above the saw-line.

It is a good practice to divide the periosteum of the tibia —and possibly also of the fibula—horizontally a little below the future saw-cut, and to separate the periosteum from the bones, together with the soft parts immediately covering them.

To effect this the interosseous membrane must be well divided, and the periosteum be cut laterally, so that it may be peeled off in flaps.

6. Retractors having been applied, the tibia and fibula must now be sawn in the manner described on page 483. The bones after division will present the appearance shown in Fig. 137.

Deep sutures having been introduced, and the flaps of periosteum adjusted, the operation is completed in the usual way.

Comment.—A good well-rounded stump results from this method. It is not adapted to withstand much direct pressure, since the scar is terminal. If the weight is to be borne upon the bent tibia, then the stump is free from reproach.

The value of the circular amputation in this section of the lower limb has been already discussed (page 461).

3. **Other Methods of Amputation.**—1. *Amputation by Equal Lateral Flaps.*—The general shape and position of the flaps are shown in Fig. 140, A. The flaps are semilunar in outline. The anterior median incision is commenced some 2 c.m. below the future saw-line, and is carried vertically downwards just to the outer side of the crest or anterior border of the tibia. The posterior incision is commenced on the back of the leg, at a point diametrically opposite to the commencement of the anterior incision.

In length each flap should slightly exceed the half-diameter of the limb at the saw-line, retraction being allowed for.

Thus, if the half-diameter be 2½ inches, or 6 c.m., the lowest curve of each flap may reach to a point 3½ inches, or 9 c.m., below the saw-line. When the skin has retracted, each flap will be found to be about 2½ inches in length.

The flaps are dissected up as skin-flaps.

A little way below the saw-line the soft parts of the limb are divided transversely down to the bones. They are then separated from the bones, and the operation is completed as in amputation by the circular method. The bones are divided as shown in Fig. 137.

This operation is merely a modification of the circular amputation. It is easier to perform. The cicatrix is terminal, and is antero-posterior instead of being transverse.

2. *Amputation by a Large Posterior Flap*, as described in the operation upon the middle of the leg (page 476), has been performed in this part of the limb.

3. *Teale's Amputation* has also been carried out at this level.

It will be seen that these procedures, especially the latter, involve the cutting of very large flaps without corresponding advantage.

AFTER-TREATMENT OF AMPUTATIONS OF THE LEG.

The stump should not be covered by the bed-clothes (*see* page 69), and the limb should be slightly raised upon a firm pillow, with the knee a little bent.

In the case of the supra-malleolar amputations, and in the amputations of the leg by a large posterior flap, the limb should be supported upon a back-splint. This splint should be applied in the manner already indicated (page 309). Care must be taken that the wound is free from pressure. In some of the circular amputations also the splint may be conveniently applied.

In the other operations the limb may be lightly secured to the pillow, the extremity of the stump projecting some little way beyond the end of the support, as in Teale's operation above the ankle. The same plan may be adopted after Farabeuf's amputation at the place of election.

The sutures should not be removed too soon, especially in cases where a posterior muscular flap has been formed, or where a single flap from the outer side of the limb has been fashioned, or where the circular method has been carried out. After the sutures are removed the flaps may possibly need to be supported by strapping.

If drainage-tubes are required, they should be introduced for a short distance only at the angles of the wound. A tube should never be inserted through the depths of the wound from one side of the stump to the other. They should be removed at the earliest possible date.

CHAPTER XXIX.

Disarticulation at the Knee-Joint.

This operation appears to have been introduced into modern practice by Velpeau in 1830, and to have been first performed in England in 1857 by Mr. S. Lane (*Lancet*, vol. ii., 1857).

It was not received with great favour, and after a while fell into disrepute. Not a few surgeons indeed considered that the operation was unjustifiable, and should never be performed.

The objections urged against it were these:—The synovial pouches which were left upon the stump suppurated and formed recesses for the accumulation of pus. The bursæ about the joint gave similar trouble. Pus spread dangerously among the loose tissues of the ham. The cartilage covering the condyles of the femur was apt to become necrosed and to be exfoliated by a very tedious process. The bone not infrequently became involved. The flaps formed were disposed to slough, and while this applied especially to the large anterior flap, it could also be frequently urged against a large posterior flap. Even if the patient survived the dangers of extensive and prolonged suppuration, and reached the time when the wound had healed, the resulting stump was still unsatisfactory It was as a rule tender, disposed to ulcerate, and unable to bear pressure.

The mortality of the operation was considerable. Panas, in a statistical table (*Dict. de Méd. et Chir. Prat.*, Art., Genou), showed that a recovery occurred in only 33 cases out of a total of 137 operations.

Since the introduction of antiseptic methods for treating wounds, and of certain improvements in the details of the operation, the whole aspect of the question has become altered.

Flaps can now be made that do not, under ordinary conditions, slough. The operation wound may heal up by first intention, or after only a very moderate degree of suppuration. Suppurative inflammation in the relics of the synovial membrane is no longer to be feared, and exfoliation of the cartilage is either not met with at all, or occurs as a very limited and quite accidental trouble. The once anxious doubt as to the fate of the articular cartilage no longer disturbs the operator's mind. It is no longer necessary to further complicate a serious operation by scraping away synovial membrane and cutting off cartilage. The patient can now bear the weight of his body upon the extremity of the stump.

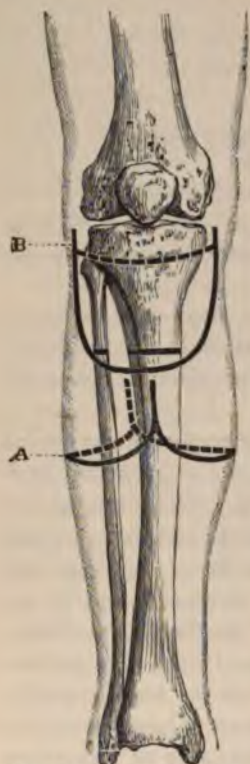

Fig. 140.—A, Amputation at "the place of election" by lateral flaps; B, Disarticulation at the knee by long anterior flap.

The mortality has also undergone a substantial improvement. Ashhurst ("Encyclopædia of Surgery," vol. i., 1882) gives the statistics of 794 examples of amputations of various kinds, both through the knee-joint itself and through the femoral condyles. The mortality is 47·7 per cent.

Bryant, in an account of 30 disarticulations at the knee-joint, performed by himself between the years 1868 and 1883, demonstrates a mortality of less than 25 per cent. Indeed, among 19 cases of disarticulation for disease, only one death is recorded as directly due to the operation (*Med.-Chir. Trans.*, vol. lxix., 1886, page 163).

This disarticulation has many advantages over the simpler and more brilliant-looking amputations through or above the femoral condyles. There is less shock, and less of the limb is removed. The section of the tissues of the limb is less, and the connective tissue planes of the thigh are not opened up. Important muscular attachments are left undisturbed, and

there is little muscular retraction. The cancellous tissue of the femur is not exposed by the saw.

The stump is an excellent one, capable of great mobility and of bearing direct pressure. This is important when it is remembered that very few indeed of the stumps resulting from amputation through the femur will bear direct pressure. Farabeuf, writing upon this point, remarks that, so far as he knows, the stumps left after amputation through the shaft of the femur can never directly transmit the weight of the body.

Before describing individual methods of procedure, it may be said that in every case it is essential that the knee-joint be free from disease. In no instance is it necessary to dissect away the remains of the synovial membrane, nor to attempt its destruction by scraping. The less the cartilage is disturbed, the better; and the practice of cutting it away from the bone is unnecessary and harmful.

Both the patella and the semilunar cartilages should be left undisturbed.

By leaving the patella the stump is rendered firmer, and its rotundity is greatly increased. Moreover, the attachments of the quadriceps are not disturbed, and the muscular strength of the stump is considerably increased. On the other hand, by dissecting out the patella much damage is inflicted upon the anterior flap. Not only is it dangerously thinned, but its blood-supply is further curtailed. It has never been shown that any evil has followed the retaining of the patella.

By leaving the semilunar cartilages in contact with the bone, the upper part of the synovial capsule is held down firmly to the condyles of the femur, and the soft parts concerned are kept well in place. Dr. Brinton advocated the leaving of the cartilages in the stump as early as 1872. "By thus leaving them in position," he writes, "I have a cap fitted upon the end of the femur, which preserves all the fascial relations, eventually prevents retraction, and guards against the projection of the condyles." Mr. Bryant endorses this advice.

Anatomical Points.—The skin over the front of the knee-joint is dense, coarse, and movable, and well supplied with blood. The subcutaneous tissues are scanty. The skin is

most loose in the position of extension. When the joint is flexed, the integuments are drawn tightly over the patella. In dissecting up an anterior skin-flap therefore, the limb is kept extended.

The vessels supplying the soft parts in front of the joint—the parts forming the large anterior flap—are the anastomotica magna, the four articular branches of the popliteal, and the anterior tibial recurrent. The last-named vessel and the two lower articular arteries are divided when the flap is cut. The most important vessels in the separated flap are those derived from the anastomotica magna.

The inter-articular line is easily demonstrated. The crease in the skin which passes transversely across the ham is some way above the line of the knee-joint. The inner condyle of the femur is much more prominent than the external, a point to be borne in mind in fashioning lateral flaps. The tubercle of the tibia and the head of the fibula are nearly upon the same level.

The synovial membrane of the knee-joint extends upwards as a *cul-de-sac*, about one inch above the upper margin of the patella. Above this pouch is a bursa between the femur and the quadriceps tendon. It measures about one inch vertically. This bursa communicates with the joint in some seven cases out of ten in children, and in about eight cases out of ten in adults.

The upper third of the patellar ligament is in relation with the synovial membrane.

The lower end of the patella corresponds roughly to the inter-articular line, when the knee is extended. To be quite precise, it is just level with the upper margin of the tibia.

The external semilunar cartilage is smaller, rounder, less firmly attached, and more movable than the internal.

At the inter-articular line the popliteal artery is descending vertically behind the middle of the joint capsule, upon which it rests. It terminates on a level with the lower part of the tubercle of the tibia. At the level of the knee-joint the popliteal vein is lying behind the artery. The internal popliteal nerve is behind the vein, and a little to its outer side. The walls of the vein are so dense and thick that on section the vessel looks almost like an artery. It is very

closely adherent to the arterial trunk. The internal saphenous vein passes along the back of the internal condyle.

The upper articular arteries run transversely outwards and inwards just above the femoral condyles. The articular vessels below the knee run respectively just below the inner tuberosity of the tibia and just above the head of the fibula. The superior external and inferior internal arteries are of fair size. The others are quite small.

The large sural arteries arise just above the joint-line.

The following **methods** are here described:—

1. Disarticulation by lateral flaps (Stephen Smith's operation).
2. Disarticulation by elliptical incision (Bauden's operation).
3. Disarticulation by long anterior flap.

1. Disarticulation by Lateral Flaps (*Stephen Smith's Operation*).—This operation, known usually as disarticulation by "lateral hooded flaps," is described in the *American Journal of Medical Sciences*, January, 1870.

The flaps consist of the integuments only, the posterior muscles being divided transversely about the level of the articulation.

Instruments.—An amputating-knife with a blade 5 to 6 inches in length; a stout scalpel; six pressure forceps; artery and dissecting forceps; retractors, scissors, etc.

Position.—The patient lies upon the back, and is so placed that the middle of the thigh rests upon the lower margin of the table. The sound limb is secured out of the way. The surgeon stands to the outer side of the right leg, to the inner side of the left. One assistant, placed at the extremity of the limb, holds the leg and manipulates it as required. The second assistant stands facing the surgeon, and attends to the flaps, the sponging, etc.

Operation.—The flaps are of somewhat semilunar outline. The incision commences in front, in the median line, about one inch below the tubercle of the tibia. It is carried in a curved manner across the most prominent part of the outer side of the leg, and is then made to slope upwards to reach the middle line at the posterior aspect of the limb. It terminates as a vertical cut opposite the centre of the inter-articular line.

A second incision begins at the same point on the front of the limb as the first, and pursues a similar direction across the inner side of the leg, meeting the first incision at the median line upon the posterior aspect of the extremity. The inner flap should be a little fuller than the outer, in order to ensure a sufficient covering for the internal condyle, which is longer and larger than the external.

The outline of the flaps is shown in Fig. 141, A.

1. The skin incisions on both the right and the left leg are more conveniently made by cutting from behind forwards. The knife is entered at the posterior aspect of the limb, at a spot opposite to the centre of the inter-articular line, and is drawn forwards, first upon one side of the limb and then upon the other, to reach the point of meeting, one inch below the tubercle of the tibia.

Fig. 141.—A, Stephen Smith's disarticulation at the knee: B, Amputation of the thigh by lateral flaps.

While the outer incision is being made the limb is rotated inwards, and *vice versâ*.

The knee-joint should be extended during the cutting of the flaps.

2. The skin is freed all round, and the two flaps are dissected up. They should include all the soft parts down to the tendons and muscles, which are well laid bare, but are as yet left uncut. The patellar ligament is cut as soon as it is reached, being divided against the tuberosity of the tibia.

The flaps are retracted to the level of the joint-line.

3. An incision is now made along the extreme upper margin of the tibia. This incision, which is transverse and concerns the anterior and lateral aspects of the bone, divides everything down to the bone, including the ilio-tibial band, the tendons of the sartorius, gracilis, semitendinosus and biceps muscles, the internal and external lateral ligaments, and, lastly, the coronary ligaments attaching the semilunar cartilages. The knife, indeed, enters the joint between the

upper surface of the tibia and these cartilages, and it is in this manner that the articulation is opened. In dividing the coronary ligaments the knife should be entered at the sides of the joint and not in front.

The knee is now flexed, and the two crucial ligaments are carefully divided from before backwards.

4. Nothing remains but to divide by a vigorous transverse cut the soft parts still connecting the leg with the thigh, viz., the posterior ligament of the joint, the popliteal vessels and nerves, the popliteus and gastrocnemius muscles, and the semi-membranosus or other undivided tendon of the ham.

Before making this final incision, the assistant who is retracting the flaps should compress the popliteal artery against the lower end of the femur.

Bryant advises that the condyloid origins of the gastrocnemius should be removed, but there appears to be no need for this step.

Fig. 142.—THE STUMP AFTER STEPHEN SMITH'S AMPUTATION AT THE KNEE - JOINT. (*After Bryant.*)

Hæmorrhage.—The popliteal artery and vein are the only vessels of any size requiring ligature. Ligatures will probably be needed for the sural arteries, the azygos artery, for branches of the superior articular vessels (especially on the outer side), and for the superficial division of the anastomotica magna (on the inner side of the limb).

Comment.—This operation provides an excellent and complete covering for the condyles of the femur. When the edges of the flaps are brought together, the wound looks directly downwards as the patient lies in bed. The stump therefore is admirably provided for in the matter of drainage.

A very serviceable extremity results. The cicatrix lies in an antero-posterior direction between the condyles, and in process of time occupies the inter-condyloid notch. Into this depression it sinks, and the prominent condyles serve to effectually protect it from pressure. It will be seen, moreover, that the scar is in time drawn towards the posterior aspect of the limb, and is thus further protected from pressure when an artificial leg is worn (Fig. 142).

Pick's Operation.—Mr. Pick (*Med. Soc. Trans.*, 1884, page 134) has devised a very similar operation to the present. Two lateral skin-flaps are made. "The incision is commenced at the upper border of the patella, and is carried down the middle line of the limb as low as the tubercle of the tibia. It is then curved outwards over the outer side of the leg to the back, and is carried upwards along the middle line to a point corresponding to the commencement of the incision on the front of the leg. A similar incision is carried round the inner side of the leg, and thus two somewhat quadrilateral flaps with rounded corners, consisting only of skin and subcutaneous tissue, are mapped out. The lowest point of the flaps is about $1\frac{1}{2}$ inch below the level of the tubercle of the tibia. They are dissected up as high as the articulation. The patella is removed, and the various structures around the joint are divided by a circular sweep of the knife."

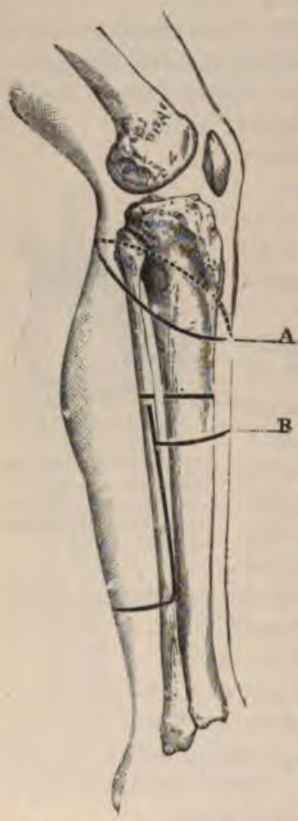

Fig. 143.—A, Disarticulation at the knee by the elliptical method (Bauden's operation); B, Henry Lee's amputation of the leg.

Compared with Stephen Smith's operation, Mr. Pick's procedure has the disadvantage of bringing the cicatrix too far forward on to the anterior aspect of the stump.

2. **Disarticulation by Elliptical Incision** (*Bauden's Operation*).—The *instruments* required and the *position* of the patient and of the surgeon are the same as in the previous operation.

The inter-articular line having been made out, the antero-posterior diameter of the limb at this line is estimated. The elliptical incision is so planned that its lowest part crosses the crest of the tibia, at a distance below the joint-line equal to

the antero-posterior diameter of the limb. The highest part of the ellipse reaches the median line posteriorly at a distance of half a diameter below the same line. The incision is inclined at an angle of about 30 degrees (Fig. 143, A).

The incision is carried through the integuments, which are then well freed along the whole extent of the wound.

The skin on the anterior aspect of the limb is turned up in the form of a cuff, while that upon the posterior side of the leg is displaced upwards by gliding merely.

By the employment of these two methods the integuments are retracted as far as the patella, the knee-joint being kept extended during the process.

The limb is now flexed a little, the patellar ligament is divided, and the articulation is entered by passing the knife between the semilunar cartilages and the head of the tibia, as in the operation last described.

Both the patella and the semilunar cartilages are preserved.

The ligaments having been divided as already described, the soft parts at the back of the joint are severed by a circular cut with the knife, made from before backwards. (*See* page 459.)

The cicatrix resulting from this operation is transverse, and is placed upon the posterior aspect of the limb. A very excellent stump is obtained.

3. **Disarticulation by Long Anterior Flap.**—This is sometimes known as Pollock's operation, the procedure having been elaborated by that surgeon.

Both of the flaps are skin-flaps, and are somewhat rectangular in outline (Fig. 140, B).

The following is Mr. Pollock's description (*Medico-Chirurgical Transactions*, vol. liii., 1870):—"I feel for the interval between the edges of the outer condyle and head of the tibia, and commence my incision at that point, and immediately behind the edge of the hamstring muscle as it crosses that space. I take especial care never to commence my incision higher than the margin of the condyle. The incision should be carried perpendicularly downwards on the side of the leg till nearly five inches below the lower edge of the patella, then gradually brought across the front of the leg,

and when crossing the tibia should be quite five inches below the patella, then carried up the inner side to a point corresponding exactly to that from which the incision commenced. I usually make the posterior flap by cutting from without inwards; it should not be too short, and should consist merely of integument. As soon as the flaps are completed, all the structures round the joint should be divided at right angles with the limb." The patella is left.

The resulting cicatrix is transverse, and is placed upon the posterior aspect of the stump.

Comment.—Other methods of disarticulating at the knee-joint may be mentioned, such as the operation by equal anterior and posterior flaps, and the operation by cutting a single long posterior flap from the soft parts of the calf. The three most noteworthy methods, however, are those just given.

Of these the best is certainly that first described—the disarticulation by lateral flaps. This operation is simple and is easily performed; it makes no great demands upon the tissues on any one side of the limb; it leaves a wound well adapted for satisfactory drainage, and an admirable stump with a well-protected cicatrix. The flaps, moreover, are well nourished.

Most of these advantages can be claimed for the second operation—that by the elliptical incision. In this procedure no great demands are made upon the soft parts of the leg, and the wound admits of satisfactory drainage. The operation, however, is not so easy to perform; the cicatrix is transverse, and is consequently not so well protected as it is in Stephen Smith's operation, where it sinks into the intercondyloid notch. By both these operations an excellent covering is provided for the condyles.

The operation by the long anterior flap was for many years the chief method employed by English surgeons for amputations at the knee-joint. The method, however, does not compare favourably with the two operations already alluded to. The long anterior flap does not in the first place provide so good a covering for the condyles. In the second instance it is of so great a length, and so thin in substance, that it is of necessity ill-nourished and liable to slough.

This circumstance offers the most serious objection to the operation. In 34 examples of disarticulation by the long anterior flap, tabulated by Bryant and Pick, sloughing followed in no less than 19 cases—*i.e.*, in 55 per cent. In some of the instances the sloughing was very extensive.

In twenty-one of Mr. Bryant's cases in which Stephen Smith's operation was performed, sloughing of the flaps occurred in only four instances, and in all of these the process was of a limited extent.

It would appear also that in the procedure by elliptical incision, sloughing is equally or even less uncommon.

The operation by the long anterior flap makes, moreover, a great demand upon one particular side of the limb, the wound is not so well adapted for spontaneous drainage, and in the resulting stump the cicatrix is not quite so favourably placed.

The long posterior flap has nothing to recommend it. The flap made is heavy and cumbrous; it is very apt to slough and to undergo considerable retraction.

The operation may be entertained in cases of localised destruction of the integuments of the front of the leg.

AFTER-TREATMENT OF AMPUTATIONS AT THE KNEE-JOINT.

The stump should not be covered up by the bed-clothes (page 69). The limb should be slightly raised upon a firm pillow. To this support the thigh should be lightly secured—in such a way that the extremity of the stump projects a little beyond the end of the pillow or cushion.

In none of the operations named is a splint required.

Excellent drainage is offered by the position of the wound, and drainage-tubes should only be used in exceptional cases. In no circumstances should a tube be passed right across the wound from one end to the other. There is often considerable strain upon the sutures, which should not be removed too soon. Silkworm-gut sutures may be left in for ten, or even fourteen, days if necessary.

CHAPTER XXX.

AMPUTATION OF THE THIGH THROUGH THE CONDYLES.

IN this operation the femur is divided at the bases of the condyles, about the level of the tubercle for the insertion of the adductor magnus tendon, or a little above that spot. The patella is removed.

Anatomical Points.—The femur at the level named is still of considerable width, and is composed of cancellous tissue. The medullary canal does not commence until the narrower part of the shaft of the bone is reached, some inches above the inter-articular line.

The trochlear surface of the femur reaches much higher up on the external than on the internal condyle. The former process is somewhat more prominent anteriorly.

A horizontal saw-cut made at the level of the adductor magnus tubercle will remove the whole of the bone carrying articular cartilage. Such a cut, indeed, just touches the upper limit of the cartilage. This saw-line also corresponds to the epiphyseal line.

The lower epiphysis does not join the shaft until the age of 20 years. In young subjects the saw should be passed, if possible, below the epiphyseal line.

The only muscular fibres attached about the bases of the condyles belong to the gastrocnemius and plantaris muscles, and to the lower part possibly of the adductor magnus.

At the level of the saw-line the gracilis and semi-tendinosus are wholly tendinous; the sartorius is still muscular, and the biceps and semi-membranosus are still in great part muscular. The popliteus arises below the level of the saw-line.

The patella is removed in the operation, and as the important fibrous expansions on either side of it, belonging to

the vasti, are divided, the quadriceps is set free, and considerable retraction of the fibres of that muscular mass must be anticipated.

The synovial pouch, extending upwards between the quadriceps and the femur, has been alluded to (page 492).

At the level of the saw-line the popliteal artery is resting obliquely against the inner segment of the bone. The vein lies behind it and to its outer side. The nerve is quite to its outer side.

Instruments.—Amputating-knife five to six inches in length as regards its blade. Stout scalpel. Butcher's saw. Retractors. Six pressure forceps. Artery and dissecting forceps; scissors, etc. Lion forceps may be required.

Position.—The position of the surgeon and of his assistants is the same as in the last series of operations (page 493).

Three **methods** will be described :—

1. Carden's operation.
2. Modification of Carden's operation.
3. Gritti's operation.

1. Carden's Operation.—Mr. Richard Carden's operation was first described in the *British Medical Journal* for April, 1864, although that surgeon had carried out the method now known by his name since 1846.

"This operation," he writes, "consists in reflecting a rounded or semi-oval flap of skin and fat from the front of the joint, dividing everything else straight down to the bone, and sawing the bone slightly above the plane of the muscles, thus forming a flat-faced stump with a bonnet of integument to fall over it. . . . The operator, standing on the right side of the leg, seizes it between the left forefinger and thumb, at the spot selected for the base of the flap, and enters the point of the knife close to his finger, bringing it round through skin and fat below the patella to the spot pressed by his thumb; then turning the edge downwards at a right angle with the line of the limb, he passes it through to the spot where it first entered, cutting outwards through everything behind the bone. The flap is then reflected, and the remainder of the soft parts divided straight down to the bone; the muscles are then slightly cleared upwards, and the saw is applied."

The procedure might be described in greater detail as follows :—

1. The incision is commenced at the most prominent part of the tuberosity of one condyle, and ends at a corresponding point on the other condyle. The cut over the front of the limb sweeps with an easy curve between these two points, and crosses the median line about the middle of the patellar ligament. The posterior incision is quite horizontal (Fig. 133, C).

The anterior cut is made first. The points of starting and ending may be marked by the thumb and forefinger, as Carden advises. The knee-joint is a little flexed as this incision is being made. In the right limb it is commenced on the inner side, and in the left extremity on the outer side. The assistant rotates the limb as the knife passes across it.

The posterior incision is made by one single transverse sweep. Both incisions should involve at first only the skin and the subcutaneous tissues.

2. The limb being extended, the anterior flap is dissected up, containing all the soft parts down to the patella and the capsule of the joint. The posterior "flap" may be a little freed and allowed to glide up, in order to aid the separation of the anterior flap.

3. The knee being flexed, the joint is opened by cutting through the quadriceps tendon just above the patella. That bone is seized by the surgeon, and the anterior capsule divided on either side. The crucial and lateral ligaments are cut. With one vigorous sweep of the knife the tissues at the posterior aspect of the limb are then divided down to the bone at the level of the hinder skin incision.

A few touches with the knife serve to entirely separate the leg.

4. The soft parts are now retracted so as to clear the bone for the passage of the saw. In dividing the femur the saw must be kept parallel to the articular surface and perpendicular to the shaft.

In young subjects regard must be had for the epiphyseal line.

Hæmorrhage.—The popliteal artery is divided close to the bone at its inner aspect. Some muscular branches may require ligature.

On the cut surface of the posterior flap will be found the two superior articular branches from the popliteal (divided close to the femur), and the anastomotica magna (on the inner side). Branches of the latter vessel and of the descending portion of the external circumflex may require to be secured in the margins of the anterior flap.

Comment.—"When the soft parts are thickened and condensed by inflammation, the integuments cannot well be reflected above the patella with such incisions of the skin. But the difficulty may be got over by cutting into the joint as soon as the ligamentum patellæ is exposed, and at once removing the leg by dividing the ligaments and hamstrings; after which the soft parts can be retracted from the femur sufficiently to permit the application of the saw. The arteries having then been secured, the patella is dissected out at leisure" (*Lister*).

2. **Modifications of Carden's Operation.**—A. *Sir Joseph Lister* ("Holmes' System of Surgery," vol. iii., 1883) writes as follows:—

"I found it advantageous to form a short posterior skin flap, both for the sake of co-aptation of the cutaneous margins without puckering, and as a useful addition to the covering for the end of the stump.

"The surgeon first cuts transversely across the front of the limb, from side to side, at the level of the anterior tuberosity of the tibia, and joins the horns of this incision posteriorly by carrying the knife at an angle of forty-five degrees to the axis of the leg through the skin and fat (Fig. 133, D). The limb being elevated, he dissects up the posterior skin-flap, and then proceeds to raise the ring of integument as in a circular operation, taking due care to avoid scoring the subcutaneous tissue, and dividing the hamstrings as soon as they are exposed; and bending the knee, he finds no difficulty in exposing the upper border of the patella. He then sinks his knife through the insertion of the quadriceps extensor, and having cleared the bone immediately above the articular cartilage, and holding the limb horizontal, he applies the saw vertically, and at the same time transversely, to the axis of the limb (not of the bone), so as to ensure a horizontal surface for the patient to rest on."

B. *Farabeuf's* modification of Carden's procedure is practically a new operation. The femur is divided at the same level, but different flaps are cut. The anterior flap exceeds in length the antero-posterior diameter of the limb at the saw-line by about an inch. The posterior flap is equal to half that diameter. The lateral incisions which mark out the anterior flap commence just below the joint-line (Fig. 144). The outer cut descends on the fibula, the inner is placed about two inches behind the inner edge of the tibia. The anterior flap, therefore, will occupy more than half the circumference of the limb.

Fig. 144.—FARABEUF'S AMPUTATION THROUGH THE CONDYLES OF THE FEMUR. A, Line of saw-cut.

The steps of the operation are precisely the same as in Carden's method. An excellent stump is provided.

The cicatrix in all these operations is found upon the posterior aspect of the limb.

3. **Gritti's Operation.**—This operation, designed by Rocco Gritti, of Milan, in 1857 (*Annali Universali di Medicina,* Milan, 1857), is an application of the osteo-plastic method of Pirogoff to amputations at the knee.

The patella is retained, but its articular surface is removed with the saw. To effect this the bone has practically to be bisected. The femur is divided transversely at the upper edge of the articular surface—*i.e.*, about the level of the adductor magnus tubercle.

The two sawn surfaces of bone are brought together, and it is presumed that they will unite, that the patella will form the summit of the stump, and that upon it the weight of the body will be borne.

Operation.—The position of the patient, and of the surgeon and his assistants, is the same as in the preceding operations. In addition to the instruments enumerated, the following are required :—A fine metacarpal saw, or small Butcher's saw, for the patella; a pair of lion forceps to hold the patella; cutting pliers, in the event of the articular surface of the

patella being removed by cutting rather than by the saw; a bone-drill; stout catgut or wire sutures or pegs for the bones.

An anterior flap is made which commences on either side at the level of the tuberosities of the femoral condyles, and which reaches below to the lowest part of the tubercle of the tibia. This flap is rectangular in outline (Fig. 131, D). The skin at the back of the limb is divided transversely or by an incision which is inclined a little downwards. The general steps of the operation are the same as those already given.

The anterior flap is dissected up as soon as the ligamentum patellæ has been divided at its insertion. This flap is turned up with the patella in it undisturbed. The knee-joint having been opened, disarticulation is effected, and the soft parts at the back of the limb are divided by a sweep of the knife. The lower end of the femur is removed with the saw. Finally, the articular surface of the patella is sawn off or removed by cutting pliers.

The parts are finally adjusted when all the bleeding points have been secured. The cicatrix is entirely posterior.

Gritti appears to have employed no especial means for keeping the two bony surfaces in close contact.

The sawing of the patella presents the only difficult step in the operation. The bone has—as it were—to be split.

The patella should be held vertically by an assistant, who grasps the anterior flap with both hands, and so holds it that the bone is made to stand out from its surface. Another assistant should steady the bone with a pair of broad lion forceps while the saw is being entered.

During the process of sawing, the surgeon should grasp the ligamentum patellæ with stout forceps, held in the left hand. In order to take advantage of this means of steadying the patella, the ligament should be cut as long as possible.

There appears to be no advantage to be gained by removing the cartilage with cutting pliers.

Sir W. Stokes has considerably modified this operation. He points out that there is always a difficulty in keeping the two bony surfaces together. These surfaces differ very materially in size, and the fragment of the patella is very apt to slide to and fro upon the wide surface of the divided condyles.

Moreover, so low down is the femur sawn that it is sometimes difficult to bring the patella in easy contact with it. The fragment of the knee-cap may have to be forced into position. The strain thus placed upon the quadriceps is soon removed by the contraction of that muscle, and the patella is drawn forwards and made to assume an oblique position. It then becomes a veritable foreign body in the stump, and has led to caries of the bones and to a tender and painful extremity. To overcome these objections Stokes divides the femur higher up—viz., at a point from half to three-quarters of an inch above the condyles. The section of the bone at this level is more nearly equal in size to that of the divided patella. At the same time it is not sufficiently high up to expose the medullary canal.

Different flaps are cut. The anterior flap is oval, and reaches from a point one inch above either condyle to a point just below the tubercle of the tibia. A posterior flap is formed, which is at least one-third of the length of the anterior flap.

The bones may be kept in position either by closely suturing the soft parts above the patella to the posterior flap, or by drilling the bones and securing them by wire or catgut sutures or by pegs.

A distinction between Gritti's operation and Stokes's modification of the same has been made by describing the former as a trans-condyloid amputation, and the latter as a supra-condyloid.

Comment.—In commenting upon these various procedures it may, in the first place, be said that the best method of removing the limb about the knee is undoubtedly by disarticulation. The advantages of this procedure, when compared with amputations through the limb immediately above the knee, have been already dealt with (page 490). When comparing the operations through the condyles (just described) with amputations through the shaft of the femur, considerable advantages must be allowed to attend the former procedures.

In the first place, the stump left after an amputation through the femoral shaft will not bear direct pressure, the weight of the body cannot be borne upon it, and the artificial limb worn must take its main support from the pelvis.

In the amputations through the condyles, a broad section of bone is left in the stump, and the skin covering the extremity is accustomed to bear pressure (as in kneeling). It follows that the stumps left after such operations can bear direct pressure, and the importance of this fact cannot well be exaggerated.

The other advantages to be claimed for these condylar operations, when compared with amputations through the shaft, are these:—The limb is removed lower down, there is less shock, and the medullary canal is not opened up. Muscular attachments are but little disturbed, and such muscles as are divided are cut in their tendinous parts, and not where the tissues are thick and vascular. The function of the adductors is scarcely at all disturbed. There is little muscular retraction, and but slight disposition for the end of the bone to protrude, or for a conical stump to result. Both these complications are not uncommon after amputations through the lower part of the thigh.

Of the methods described, Carden's operation is probably the best. If, however, the flaps are cut precisely as Carden directed, they will often be found to provide but a scanty covering for the bones. This operation, when performed upon the cadaver, appears to be in every respect admirable, but it is a little less satisfactory on the living. A flap cut from the front of the knee in the living subject will retract one-third of its length after it has been separated from the deeper parts. Thus a flap six inches in length will shorten to one of four inches.

Either of the two modifications of Carden's operation is to be recommended in the place of the original procedure. They both give admirable results.

Considerable differences of opinion have been expressed as to the value of Gritti's operation. There is no evidence to show that the presence of the patella in the stump adds very greatly to its usefulness, nor improves its capacity for bearing pressure. Against the operation as described by Gritti, the objections already detailed in the description of the procedure must be urged. These objections are met by Stokes's modification of the method. Excellent results have been obtained by Stokes's operation. One great point in its favour depends

upon the circumstance that the soft parts in the anterior flap are but little disturbed, and the risks of sloughing of that flap are reduced to a minimum.

The importance of retaining the attachment of the quadriceps has perhaps been a little exaggerated. The wasting of that muscle after Stokes's operation would appear to be as great as after the amputation by Carden's method.

CHAPTER XXXI.

Amputation of the Thigh.

The operations so named concern amputation through the shaft of the femur, and occupy an intermediate position between disarticulation at the hip-joint on the one hand, and the supra-condyloid or trans-condyloid operations on the other. For the most part they involve a division of the bone at or below its centre. The sub-trochanteric amputation is seldom performed.

These operations play a conspicuous part in surgery, being performed for many injuries and diseases of the leg, and notably also for affections of the knee-joint and of the popliteal region.

Practically, every known form of amputation has been carried out in this part of the limb, and nearly every method—excepting that by a large posterior flap—has received a certain degree of support.

The procedures themselves are involved under a very exuberant and complicated nomenclature. Operations in all essential features alike, have been separately designed by independent surgeons, and where the names of the authors have been retained no little confusion has resulted.

Recognised methods have been modified in so many ways that a classification of all known amputations of the thigh becomes exceedingly involved.

No particular advantage, however, would appear to attend the attempt to define the distinctive features of such operations as those of Spence, Sédillot, Benjamin, Bell, and O'Halloran, or to retain the names of those distinguished surgeons in association with specific methods.

Considerable differences of opinion exist as to the comparative merits of the various amputations in this region,

and many of the statements made by most competent men are not reconcilable.

One surgeon (Stimson), in his account of these operations, makes no mention of the circular amputation, and states that "the superiority of the flap operation (in this part of the limb) is now generally admitted." Another writer (Guérin), dealing with the same region, observes, "L'amputation de la cuisse est le triomphe de la méthode circulaire."

In the account which follows, it has only been possible to make a selection from the twenty and more "recognised methods."

Anatomical Points.—The outline of the diaphysis of the femur is well known. The medullary cavity, as a distinct canal, occupies about the middle two-fourths of the shaft of the bone. The nutrient canal is found upon the linea aspera, a little way above the centre of the shaft. The vessel it contains is directed towards the hip.

The skin of the thigh is somewhat coarse and thick upon the outer side of the limb, and is thinner and finer on the inner aspect. It is but loosely attached to the parts beneath, and thus it follows that flaps composed of the integuments contract considerably. The skin is a little more firmly connected with the deeper parts along the groove between the vastus externus and the hamstrings, this being the situation of the outer inter-muscular septum.

The whole limb is invested by the dense fascia lata, which is thinnest on the inner aspect of the thigh, and thickest externally. On the latter surface of the limb is the ilio-tibial band.

In muscular subjects the outline of the thigh is irregular on section; in stout and non-muscular individuals, and in young children, it is more or less evenly rounded.

The great mass of the muscular tissue of the part has some attachment to the femur. Certain muscles, however—viz., the hamstrings, the gracilis, and the sartorius—are free. Of these the biceps is the least separate, being connected with the femur below the centre of the bone by means of its "short head." It happens, therefore, that the thigh muscles retract very unequally when divided, retraction being conspicuous upon the posterior and internal aspects of the limb.

In a section (Braune) through the thigh at its *upper*

third—just below the lesser trochanter—the bone is found to be well and evenly covered with muscles in front, behind, and on the inner side. It comes nearest to the skin at the outer aspect of the thigh. The muscular masses are extensive, and a considerable portion of the gluteus maximus comes into the section.

When the limb is divided transversely through the *middle of the femur*, it will be found that the bone is evenly surrounded, and is about the centre of the section. The main muscular masses are formed by the vasti, the crureus and the adductor magnus. The section of the last-named muscle is nearly equal in extent to that of the three hamstrings taken together at this level. The biceps and semi-tendinosus are here quite separate. The short head of the biceps is commencing. The adductor longus is small, and the adductor brevis has disappeared. The linea aspera is most prominent at this part of the shaft.

A transverse section at the *lower third*—about a hand's-breadth above the knee—shows that the bone is now nearest to the skin on the anterior aspect of the limb. The great bulk of the muscle tissue is behind the bone. The adductor longus has disappeared; the quadriceps is very much reduced; the biceps and semi-membranosus still present large surfaces on section; the semi-tendinosus is small; the adductor magnus is considerably reduced, and is becoming entirely free of the femur.

The femoral artery ceases at the commencement of the lower fourth of the thigh. In antero-posterior flaps the vessel comes in the anterior flap when above the centre of the limb, and in the posterior when below that point.

At the apex of Scarpa's triangle the femoral vein lies behind the artery; below that spot it is found somewhat on the outer side of that trunk.

The internal saphenous nerve accompanies the artery, lying upon its anterior surface. Care must be taken that it is not included in the ligature when the artery is secured.

The profunda artery terminates at the commencement of the lower third of the thigh. The femoral and profunda veins and the adductor longus are interposed between it and the femoral trunk.

The anastomotica magna arises from the femoral just before it terminates. The superficial branch of the vessel is accompanied to the inner side of the knee by the long saphenous nerve.

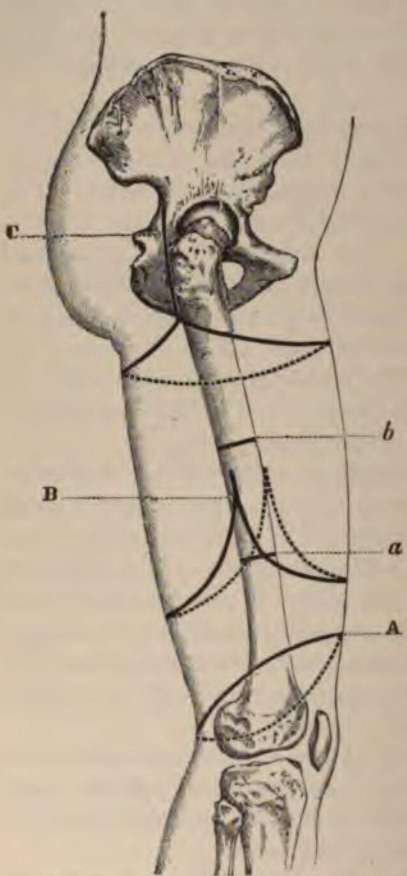

Fig. 145.—A, Circular amputation of thigh: (a) Saw-line of same; B, Amputation of thigh by equal antero-posterior flaps: (b) Saw-line of same; C, Disarticulation at the hip by external racket incision.

The descending branch of the external circumflex artery reaches to the outer side of the knee.

The following **methods** of amputating the thigh will be described:—

1. Circular method.
2. Syme's modification of the circular method.
3. By long anterior and short posterior flaps.
4. Teale's operation.
5. By equal antero-posterior flaps.
6. By lateral flaps.

The comparative value of these different methods and their applicability to different portions of the thigh, are considered on page 522.

Instruments. — Large amputating-knives. (For the circular operation the blade should be about 7 or 8 inches in length, and for cutting flaps by transfixion about 9 to 10 inches. These measurements refer to the amputation as applied to the average adult limb. In marking out skin-flaps, and in dissecting up the integuments in the circular operation, a stout knife with a broad blade 4 inches in length and a well-rounded point should be used. No attempt should be made

to complete the circular amputation with one long knife. In shaping muscular flaps by cutting—as distinguished from transfixion—the stout knife with a four-inch blade should be employed. The same knife may be conveniently used to clear the bone for the saw—*e.g.*, after transfixion flaps have been cut.) A full-sized amputation-saw. A small Butcher's saw, to shape the end of the divided femur. A dozen pressure forceps. Artery and dissecting forceps. Retractors, scissors, needles, etc.

Position.—The patient's buttocks rest upon the end of the table. The sound leg is secured out of the way. Means should be taken to prevent the body from slipping off the table. The surgeon stands to the right of the limb in the case of either extremity. (He will always be able to place himself to the outer side of the right limb; but if there should be any obstacle in the way of his standing to the inner side of the left thigh, it will be found that he can operate from the outer side without greatly increased difficulty.)

One assistant sits beyond the end of the table, to hold and manipulate the limb. A second assistant stands to the surgeon's left (or to his right if the operator be placed to the outer side of the left limb); his duties are to retract the skin (in the circular operation), to grasp the flaps when cut, to apply the retractors, and to hold the stump up while the arteries are being secured. The third assistant stands below the surgeon and attends to the sponging and the securing of the bleeding points.

1. **The Circular Amputation.**—Owing to the unequal manner in which the divided muscles retract, the simple circular operation is not adapted for the thigh. In order to allow for this irregular retraction, the incision must be placed obliquely.

This operation should only be carried out in the lower third of the limb. Farabeuf gives the following directions for the incision:—

On the anterior and outer aspects of the limb the distance between the level of the proposed saw-cut and the incision on the skin should be equal to one-fourth of the circumference of the thigh at the former point. On the hinder and inner

aspects of the limb the skin-incision should be made a little less than half this length lower down (Fig. 145, A).

For example: if the circumference of the thigh at the proposed saw-level be 18 inches, the skin-incision in front and on the outer side should be 4½ inches below that level, while on the posterior and inner aspects of the limb it should be 6¼ inches below the same point.

Operation.—The proposed incision should be marked upon the skin.

1. Standing to the outer side of the right thigh, the surgeon passes his arm beneath the limb, and, bringing his hand as far as possible over the front of the thigh, he begins the incision in the skin with the heel of the knife, at a spot as low down upon the external surface as can be reached. The assistant at the same time has the limb rotated forcibly inwards. The knife is now made to pass across the anterior, internal and posterior surfaces of the limb (in order), being drawn from the heel to the point. The assistant rotates the thigh in an opposite direction as the knife passes round, the limb being fully rotated outwards when the incision is completed. If the skin-cut be not made at one sweep, the ends of the wound should be joined by an incision from above downwards.

The surgeon, standing on the inner side of the left thigh, follows a precisely opposite course, the incision being commenced upon the inner aspect of the limb.

2. The assistant now retracts the skin while the surgeon frees it all round. It must be retracted evenly, so as to preserve the original obliquity of the incision. It is seldom possible to turn back a cuff of skin as some advise. In a normal adult limb such a course is mechanically impracticable.

3. When the skin has been separated from the deeper parts and retracted as far as required, the superficial muscles on the inner and posterior aspects of the thigh (the hamstrings, sartorius and gracilis) are divided by a vigorous sweep of the knife. When they have retracted, the deeper muscles are severed down to the bone at the highest possible level by another sweeping cut.

In dividing the muscles the obliquity of the original incision is still maintained—*i.e.* the knife crosses the limb

parallel to the original skin-cut, and as close as possible to the now retracted margin of the integument.

4. The bone is cleared, retractors are applied, and the femur is sawn through. "In sawing the femur the position of the thick ridge (linea aspera) at its posterior aspect is to be remembered, and the saw, at first horizontal, must be brought nearly vertical so soon as a groove is cut, in order that the linea aspera may be divided early, and not left to break and form a projecting spike" (*C. Heath*).

It is well to saw off the superior and inferior margins of the end of the bone obliquely, so as to round it. This may be conveniently performed by a small Butcher's saw.

The cicatrix will be transverse or oblique. In the latter case it will incline from in front backwards and inwards.

Hæmorrhage.—The position of the femoral artery upon the face of the stump will depend upon the level at which the tissues are divided.

If the amputation be through the lower third of the thigh, the anastomotica magna will be divided. If above this level, the profunda will be found to be cut. The descending branch of the external circumflex artery will require a ligature as it lies cut on the antero-external aspect of the stump. One or more of the perforating arteries and many muscular branches may need to be secured.

2. **Syme's Modification of the Circular Amputation.**—By this method the circular operation is simplified. The skin is much more easily dissected up, and the integuments are less roughly handled in the process of separation.

The *operation* consists practically of the usual circular incision, with two lateral cuts to aid the retraction of the skin.

Two very short antero-posterior flaps of semilunar outline and of equal width and length are dissected up. They are composed simply of the integument and subcutaneous tissues, and consist of little more than curved incisions made across the front and the back of the thigh, each being equal to one-half of the circumference of the limb.

The skin beyond the little flaps is, in its turn, separated—just as in the usual circular method—and is reflected until a point is reached some two inches above the bases of the small antero-posterior flaps.

The anterior femoral muscles are now divided down to the bone by a transverse sweep of the knife at the level of the retracted skin. The posterior muscles are severed in like manner, but at the level at which they were first uncovered in forming the posterior flap.

"The muscles," as Syme puts it, "should be divided right down to the bone, on a level as high as they are exposed in front, as low as they are exposed behind."

The muscular tissue after division is further retracted, so as to clear the bone well. The femur is ultimately sawn about two inches above the level of the spot at which the anterior muscles were divided.

3. **Amputation by Long Anterior and Short Posterior Flaps.**—The following is the description of this operation as given by Farabeuf. His method is a slight modification of that associated with Spence's name. An excellent covering for the bone is provided.

The position of the surgeon and his assistants and the instruments used have been already detailed.

It is assumed that the femur is to be divided about its centre. The two flaps are U-shaped. The anterior flap is equal in length to one diameter and a half of the limb at the saw-line. The posterior flap has the length of one-half the diameter of the extremity at the same level. The anterior flap is the wider, its base exceeding a little half the circumference of the limb (Fig. 146, A).

Operation.—1. The limb is rotated outwards on the right side, and inwards on the left. The anterior flap is marked out first. In the right thigh the surgeon commences with the inner limb of the flap, cutting downwards. He then carries the knife across the front of the extremity, and finishes with the outer limb of the flap, the leg being now rotated inwards. In dealing with the left limb the conditions are reversed, and the cut is first made upon the external aspect. The incision includes the integuments only.

In marking out the posterior flap the surgeon's hand is beneath the thigh, and the knife, being entered at the further limb of the anterior flap, is drawn across the posterior surface and towards the operator. This cut also involves the integuments only.

The leg is again suitably rotated as the knife passes along its course.

2. The tissues of the anterior flap are now pinched up with the left hand, and the muscles contained therein are divided obliquely from without inwards —*i.e.*, from the skin to the bone. The soft parts are so cut that the flap is thinnest at its extremity and thickest at its base. At the latter site it will include the whole thickness of the muscular mass in front of the femur. The tissues are divided obliquely (the edge of the knife being turned towards the bone at the base of the flap) in distinction to the transverse division of parts which obtains in the circular amputation.

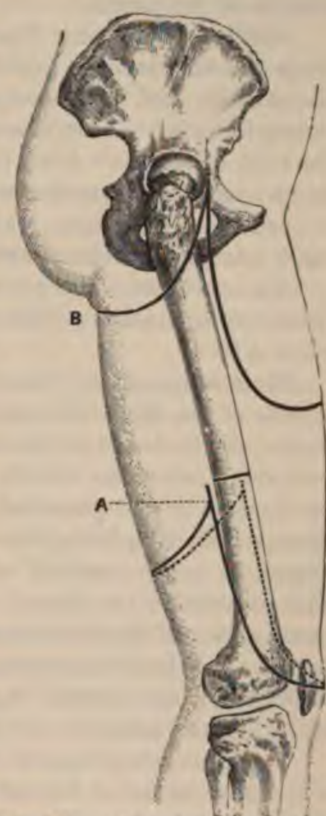

Fig. 146.—A, Amputation of the thigh by long anterior and short posterior flaps; B, Disarticulation at the hip by antero-posterior flaps.

The muscles of the posterior flap may be conveniently cut by transfixion. They may, however, be divided in the same way as are those of the anterior flap. Transfixion is better suited for muscular limbs.

The muscles are divided well down to the bone at the bases of the flaps. The femur is bared by further retraction of the soft parts, and is sawn in the manner already described (page 515).

Spence ("Lectures on Surgery," 2nd ed., vol. ii., page 621, 1876) made the anterior flap equal in length to the diameter of the limb, and the breadth of its base equal to "almost two-thirds of the circumference of the thigh."

The posterior flap was cut from without inwards, and was commenced some two inches below the base of the anterior

flap. To this an additional inch of skin was sometimes added Spence considered this operation as especially applicable to the lower third of the thigh, and the extremity of the large anterior flap was allowed to reach as low as the lower margin of the patella.

Sédillot ("Médecine Opératoire," vol. i., page 455, 1854) made the anterior flap equal to one diameter of the limb at the saw-line, and its base equivalent to "fully one-half of the circumference." There was no posterior flap, the structures at the back of the limb, from the skin to the bone, being divided by one vigorous transverse cut.

Sédillot's operation, when performed upon a muscular limb, scarcely provides a sufficient covering for the bone.

Hæmorrhage.—The position of the femoral artery, with reference to antero-posterior flaps generally, may here be alluded to.

In an amputation by antero-posterior flaps made above the middle of the thigh, the femoral artery, together with the profunda, will be found in the anterior flap. In a like amputation performed below the middle of the limb the main artery will be divided in the posterior flap. In this position, however, there is risk of splitting the artery if the anterior flap much exceed in width one-half of the circumference of the limb. This is avoided by placing this flap a little towards the external aspect of the limb instead of fashioning it in the median segment. When the amputation is carried out in the middle of the thigh, the anterior flap should be antero-external. This will bring the artery in the posterior flap.

The descending branch of the external circumflex artery will always be found divided in the anterior flap, together with many muscular branches. In the lower third of the limb the anastomotica magna will be divided about the inner part of the hinder flap.

In the angle between the flaps, and in the muscular tissue close to the bone, branches of the perforating arteries will be found cut.

It is needless to say that the muscular arteries in the thigh are large and numerous, and that the great veins require to be occluded by ligature.

4. **Teale's Operation.**—This procedure when applied to

the thigh, is carried out upon precisely the same bases as have been already given (page 469). The anterior flap is equal in width and in length to one-half of the circumference of the limb at the level of the saw-line.

The posterior flap is one-fourth of the length of the anterior.

Both flaps are rectangular and are composed of the integuments only. The anterior flap can be carried well down over the patellar region. Care must be taken that this flap does not become narrow as it descends.

5. **Amputation by Equal Antero-Posterior Flaps.**—This may be taken as a type of the amputation of the thigh by transfixion. The surgeon stands to the right side of the limb in the case of both the right and the left thighs. The length of the amputating-knife must be influenced by the width of the limb.

In order that the flaps should be of equal length after they are cut, it is necessary that the posterior flap should be made a little the longer. This is to allow for the greater retraction of the posterior muscles.

Both flaps are U-shaped, and the base of each is equal to one-half the circumference of the limb. The posterior flap should be the length of the diameter of the thigh at the saw-line. The anterior flap will be equal to about three-fourths of that diameter (Fig. 145, B). Fergusson's rule was that the hinder flap should be one inch longer than the anterior one. These measurements will be found to about coincide with the advice given in older books—to the effect that in the adult the flaps should be from 4 to 4½ inches in length.

The *operation* is performed in the usual way (page 297).

"Grasping the soft parts," writes Fergusson, "so as to bring them well forward, I push the knife across from the outside and form a flap in front; this being slightly elevated, I again carry the knife in the direction which it first took, but behind the bone, and form the second flap from the posterior surface."

It is important that the anterior flap should be of its proper width. In performing transfixion carelessly, this flap is apt to be made a great deal narrower and thinner than the posterior one. Before the knife is introduced the exact limits of the

base of the anterior flap should be marked out. The substance of the future flap is grasped between the fingers and thumb of the left hand. The thumb and forefinger, indeed, mark the base of the flap.

After the flaps have been dissected up, the muscular tissue about the bone is divided with a stout scalpel. The flaps, with the severed tissues occupying the angle between them, are evenly retracted until the femur is exposed at the spot at which the saw is to be applied.

In very muscular limbs the knife, in transfixing the part, may be kept a little away from the bone, so that only the more superficial muscles are divided. This especially applies to the cutting of the posterior flap. When this has been done, the deeper muscles are severed by transverse cuts, as in the circular operation.

Directions for sawing the bone have been already given.

Some of the objections which apply to the flap method are overcome by cutting the flaps from without inwards, precisely after the manner described in the account of the amputation by the long anterior flap (page 517).

Hæmorrhage.—This point has been already considered (page 518).

When planning the flaps attention must be paid to the position of the main blood-vessels.

6. **Amputation by Lateral Flaps.**—This method is often known as Vermale's operation.

It appears to have been at one time extensively practised. It has been considered to be especially applicable to the lower third of the limb.

The flaps are both of the same size, and include all the soft parts down to the bone. It may be convenient to make the inner flap a little wider than the outer, so as to include as much of the artery as possible in the inner flap.

Each flap should be equal in length to the diameter of the limb at the level of the saw-cut, and should be **U**-shaped (Fig. 141, B).

Both are cut by transfixion, the knife being entered a little below the point at which the bone is to be divided.

Operation.—The following is Fergusson's account of the operation :—

"The surgeon, standing on the outside of the limb, should grasp the soft parts on the outer side of the thigh between his fingers and thumb, and having drawn them as it were from the side of the bone, should pass the knife from before backwards—or, rather, from above downwards—and then cut downwards and outwards so as to form a flap of the size indicated (Fig. **141**, B). Next the knife should a second time be introduced in front, and carried backwards in a line with its original course, but on the opposite side of the bone, when by cutting again downwards and towards the surface, the inner flap is formed. Both of them should then be drawn upwards with considerable force by the hands of an assistant, and an incision made round the bone, fully an inch higher than the place of transfixion. The saw should then be applied in the course of this last cut. In transfixing, the point of the knife should be thrust directly down to the femur, with which it should be kept in close contact as it is carried round to the opposite surface.

"The assistant, who has charge of the flaps should not forcibly elevate the one first made, as the knife is thereby prevented from passing readily across the limb the second time. He can scarcely, however, be too energetic—after the other is cut—in drawing both upwards, so as to give plenty of room for working the saw without rubbing against the soft parts.

"I am generally in the habit of making the inner flap first instead of the outer, as I can thereby see the progress of the knife much more clearly during the second thrust."

In this operation, when performed in the lower third, the main artery is very apt to be split, even when every precaution is taken.

Comment.—Owing to the uneven manner in which the muscles of the part retract, and to the extent of that retraction, a conical stump is not uncommon after any amputation of the thigh.

The retraction concerns mainly the posterior and internal segments of the limb, and it will be observed that the cicatrix is apt to be drawn backwards and to the inner side. This may be well seen after a simple circular amputation.

Conical stumps are more common below than above the middle of the limb.

In amputations made through the lower third of the thigh it should be remembered that the bone comes nearest to the anterior surface.

When the limb is divided above the middle of the thigh, the femur is apt to project anteriorly. This is due partly to the contraction of the psoas and iliacus muscles, and partly to the weight and retraction of the posterior muscles.

With regard to the *selection of methods* :—

The objections which have been urged against the circular operation, and the advantages which it may claim (page 301), apply very especially to amputations in this region.

The usual circular method cannot be advised, nor is any form of the amputation suited for the middle or higher part of the limb.

The modified circular operation described (No. 1) and Syme's operation (No. 2) are adapted for the lower third of the limb, especially in cases where a long anterior flap cannot be cut, for children, and for the limbs of enfeebled and wasted subjects. The fact that the wound-surface is comparatively small, that the section of the muscles is reduced to a minimum, and that the main vessels are cleanly divided, are distinctly in favour of this method.

There is little to recommend Teale's operation (No. 4) in this section of the limb. It is adapted only for the lower third. It certainly ensures a good covering for the bone and a clean division of the main artery. It may be of value when the parts upon the posterior aspect of the limb are damaged. It has, however, these disadvantages : the anterior flap is long and thin, and apt to slough; in any case, its edges at least are apt to become gangrenous. The large flap is, moreover, difficult to adjust and to keep in place.

The amputation by a long anterior and a short posterior flap (No. 3) is perhaps the best adapted for the thigh and all parts of it.

In the lower third of the limb it is certainly an excellent operation. Where the tissues upon the front of the thigh are limited, it may be replaced by the method by two equal antero-posterior flaps (No. 5), the flaps being cut in the same manner—*i.e.*, from without inwards.

Amputation by transfixion has already been discussed (page

302), and the advantages and disadvantages presented by the operation are conspicuously evident in this part of the body.

Vermale's operation (No. 6) was at one time extensively practised. It has, however, very little to recommend it. The stump looks well when the operation has been performed upon the cadaver, but in the living subject it will be found that the end of the femur has a great tendency to project forward between the flaps. The bone, indeed, cannot be well covered. It is difficult to cut the flaps neatly by transfixion; they are apt to retract unequally, and it is not unusual to find that the great vessels have been split or divided unduly high up in fashioning the internal flap.

In some limited injuries, as, for example, in a gunshot wound involving the front of the limb, the operation may be considered of service. It is, however, the least satisfactory of the methods here described.

AFTER-TREATMENT OF AMPUTATIONS OF THE THIGH.

The stump should be exposed to the air—covered, of course, by suitable dressings (page 69). The thigh should be raised and supported upon a firm pillow or cushion, to which it should be lightly secured. The limb should be placed in the abducted position. The extremity of the stump should project beyond the end of the pillow. It will be thereby exempted from pressure, and drainage will not be interfered with. A supporting splint is not required in these amputations, although it may sometimes be employed with advantage after the circular operation and in amputations through the lower part of the limb.

It is scarcely to be expected that these large wounds will heal up throughout by first intention. A few sutures should be omitted at the most dependent angle of the wound, to allow for drainage—or, better still, a short tube may be inserted at that situation. The oozing during the first twenty-four hours is considerable.

In no case should a large drainage-tube be drawn right through the depths of the wound, from one extremity of the incision to the other.

As the flaps are large and heavy, the sutures should not be removed too soon. After their removal the flaps may need to be supported for a while by strapping.

CHAPTER XXXII.

Disarticulation at the Hip-Joint.

This amputation, the most serious the surgeon can be called upon to perform, was for many years after its introduction attended by so terrible a mortality as to be considered an entirely unjustifiable operation.

The first amputation at the hip appears to have been performed by Mr. Henry Thompson, surgeon to the London Hospital, some time before 1777. Previous to this—viz., in 1743—Ravaton had elaborated an operation, which, however, his surgical colleagues would not allow him to perform. His method consisted in a vertical external incision, through which the bone was to be enucleated subperiosteally, and disarticulation effected; the operation was to be completed by a circular section of the soft parts. This procedure is practically identical with the modern operations of Esmarch, Lister, Furneaux Jordan, and others (page 531).

Kerr, of Northampton, amputated at the hip in 1778, using an oval incision, the *queue* of which terminated externally. Through the outer part of the wound disarticulation was effected, the soft parts upon the inner side of the limb being divided subsequently.

The first amputation at the hip in military practice is accredited to Baron Larrey in 1793. In all these early cases the patient died.

Earle, writing in 1808 ("Potts' Chirurgical Works," vol. iii., page 217), speaks of the operation as "horrid," "dreadful," and "unjustifiable," and adds: "I have seen it done, and am now very sure I shall never do it unless it be on a dead body."

The mortality after this operation has been already considered (page 316).

In designing the operation in any particular case, allowance must be made for the great retractility of the skin in

this part of the limb, and for the contraction of the divided muscles.

The artificial limb worn after the operation must, of course, take its support from the pelvis, and principally from the ischium. It is well, therefore, that there should be a good internal flap, and that the cicatrix should be removed from the tuber ischii. At the same time, the operation wound must be so arranged as to allow for efficient drainage.

In this amputation no little value must attach to methods of operation which can be effected with rapidity.

Anatomical Points.—The following landmarks may be noted:—The pubic spine is on a level with the great trochanter. The summit of the great trochanter is on a level with the centre of the hip-joint. The gluteal fold is some way above the lower margin of the gluteus maximus muscle, with which it does not correspond.

The subcutaneous tissue about the hip is lax.

The following are the muscles attached to the upper third of the femur:—The three glutei, the two obturator muscles, the two gemelli, the pyriformis, the psoas and iliacus, the pectineus, the adductor brevis and adductor magnus, the quadratus femoris, and portions of the vasti and crureus.

The remaining muscles divided in the operation are the tensor vaginæ femoris, the rectus, the sartorius, the gracilis, the adductor longus, and the three hamstring muscles.

Several bursæ exist about the hip, the largest and most noteworthy being one between the great trochanter and the gluteus maximus, and another between that muscle and the vastus externus.

The hip capsule is thickest in front, at the site of the ilio-femoral ligament. It may here measure one-fourth of an inch in section.

The femoral artery is separated from the capsule of the hip by the psoas muscle, upon which it lies. The profunda arises one inch and a half below Poupart's ligament; the internal and external circumflex arteries two inches below that ligament. At the apex of Scarpa's triangle—some three to four inches below Poupart's line—the great vessels have the following relation to one another from before backwards: femoral artery, femoral vein, profunda artery, profunda vein.

The profunda is about the size of the brachial artery, the external circumflex of the ulnar, the internal circumflex of the lingual.

The last-named vessel runs horizontally backwards through the substance of the limb, about the level of the lesser trochanter. It gives a branch to the hip-joint.

The external circumflex artery passes more or less directly outwards.

The first perforating artery runs backward at the lower border of the pectineus muscle.

The sciatic artery gives off numerous branches, most of which are cut in the amputation. The comes nervi ischiadici —the terminal part of the vessel—is the size of the supra-orbital artery.

No large branch of the gluteal artery is divided, although the inferior branch of the deep division will be cut near its extremity.

The obturator artery itself is not concerned in the operation, and the branches of it which are divided are very small *e.g.*, the branches to the adductors and to the hip.

In the hollow on the inner side of the great trochanter is an anastomotic network which is derived from the gluteal, sciatic, internal circumflex, and first perforating arteries.

Mode of Controlling Hæmorrhage during the Operation.

Various methods have been adopted for preventing excessive hæmorrhage during this disarticulation.

1. The femoral artery may be ligatured either before the flaps are cut (page 534) or during the fashioning of the flaps when the incision crosses the line of the artery, as in the method known as the "anterior racket" (page 537).

The procedure involves a little time, and, when a special incision has to be made, somewhat complicates the operation. The method, however, has many advantages. It has been urged that the artery is apt to be secured unnecessarily high up, and that the vitality of the main flap may be in consequence impaired; but this objection has not been confirmed by practice.

The femoral may be compressed in the flap by the

fingers of an assistant, who grasps the base of the flap just before the vessels are divided. This method is illustrated in the amputation by transfixion (page 540).

Some surgeons advise digital compression of the femoral or external iliac. This can, however, hardly be carried out except in a child. The fingers are very apt to slip during the manipulation of the limb.

In all these methods it is needless to say that the securing of the femoral does not affect hæmorrhage from the branches of the internal iliac artery.

2. Lister's aortic tourniquet has been employed. The use of this instrument is now no longer advised by its author. It cannot be used in stout or very muscular subjects. It is very difficult to maintain in position, and is apt, if firmly applied, to do damage to the intestine.

3. Davy's lever for compressing the common iliac through the rectum has been extensively used in this operation. It consists of a smooth rod or cylinder of ebony-wood or metal, from eighteen to twenty inches in length, and terminating in a conical blunt extremity. Oil having been injected into the bowel, the conical or larger end of the lever is introduced into the rectum, and is passed in the direction of the vessel to be compressed. The surgeon, feeling the end of the instrument through the abdominal parietes, directs it to the common iliac as it lies on the pelvic brim. The handle of the instrument is now carried to the thigh of the opposite side, and is then raised so that it may act as a lever, for which the anus serves as a fulcrum.

Mr. Davy (*British Medical Journal*, vol. ii., 1879, page 685) claims that this instrument is most efficient—as proved by a number of cases—that it is simple and readily applied, and is easily maintained in position. The following objections may, however, be urged against this ingenious compressor:—The assistant who manipulates it is a little in the way of the surgeon and of those who are taking part in the operation. The lever could scarcely be applied in cases where no meso-rectum existed. It is of course useless if the coats of the rectum are unsound. Sir Joseph Lister mentions "a case in which a gentleman specially conversant with the use of the lever failed to bring it into effective action, and another case

. . . where death resulted from mischief done by the end of the rod working in the dark."

4. The elastic tourniquet furnishes without doubt an efficient means of controlling bleeding during this operation.

The band may be applied either over the abdominal aorta or around the extreme upper part of the limb. Its application in the former situation is thus described by Sir Joseph Lister ("Holmes' System of Surgery," vol. iii., page 722):—"For the aorta a pad of sufficient size, such as a pin-cushion, adjusted over the vessel about the level of the iliac crest, is pressed down by elastic bands, which, however, ought not to encircle the body directly and so cause inconvenient constriction of the waist, but should be connected with the ends of a rigid object placed transversely beneath the back and extending laterally sufficiently far to protect the sides of the body from compression. A narrow piece of board, with two lateral notches at each end, would answer the purpose quite well for an emergency as a substitute for the curved piece of stout iron, with rings and hooks at the ends, recommended by Esmarch."

The application of the elastic band to the upper part of the thigh is thus described by Mr. Jordon Lloyd (*Lancet*, vol. i., 1883, page 897):—

"The limb about to be operated upon should first be emptied of blood by elevation. This will occupy only a few minutes, and may be executed during the administration of the anæsthetic. A strip of black india-rubber bandage about two yards long is to be doubled and passed between the thighs, its centre lying between the tuber ischii of the side to be operated on and the anus. A common calico thigh-roller must next be laid lengthways over the external iliac artery. The ends of the rubber are now to be firmly and steadily drawn in a direction upwards and outwards, one in front and one behind, to a point above the centre of the iliac crest of the same side. They must not be pulled tight enough to check pulsation in the femoral artery. The front part of the band, passing across the compress, occludes the external iliac, and runs parallel to and above Poupart's ligament. The back half of the band runs across the great sacro-sciatic notch, and, by compressing the vessels passing through it, prevents bleeding from the branches of the internal iliac artery.

"The ends of the bandage thus tightened must be held by the hand of an assistant, placed just above the centre of the iliac crest, the back of the hand being against the surface of the patient's body. In this way an elastic tourniquet is made to encircle one of the innominate bones, checking the whole blood-supply to the lower extremity. When the band is once properly adjusted, the assistant has only to take care that it does not slip away from the compress or over the tuber ischii. The former is prevented by securing pad and tourniquet together with a stout safety-pin, and the latter by keeping the securing hand well above the iliac crest; and even more safely by looping a tape beneath the elastic near the tuber ischii, passing it behind under the sacrum, and having it held in that position. The solid rubber tourniquet may be used instead of this bandage. I prefer, however, the bandage. The soft parts are less damaged by reason of its greater breadth, and it is less likely to roll off the compress placed over the external iliac.

"The ligature, being altogether above the limb, is out of the way of the surgeon in any operation at or about the hip-joint. The great trochanter is fully exposed, the hip being free upwards as far as the iliac crest, and inwards to the perineum. The plan is applicable to amputation by transfixion or to excision of the joint."

5. The use of long needles or skewers has been advised or adopted by a few operators. Trendelenburg transfixes the thigh by a single needle passed in front of the neck of the femur and beneath the vessels. Over the ends of the needle and in front of the thigh a compressing rubber cord is carried. Mr. Myles (*Brit. Med. Journ.*, Nov. 9, 1889) advises the following method:—A stout steel skewer is thrust straight through the thigh from before backwards. Its point enters an inch below Poupart's ligament, and just to the outer side of the femoral artery it passes to the inner side of the neck of the femur, and emerges a little above the gluteal fold. An india-rubber cord is now passed in the form of a figure of 8 around the projecting ends of the skewer. The amputation is effected by means of lateral flaps.

Dr. Wyeth (*Internat. Journ. of Surg.*, July, 1890) uses two needles for the purpose of fixing an Esmarch's band in position.

Two steel mattress-needles, three-sixteenths of an inch in diameter and a foot long, are used. The point of one is inserted an inch and a half below, and just to the inner side of, the anterior superior iliac spine, and is made to traverse the muscles, passing about half-way between the great trochanter and the iliac spine, external to the neck of the femur, and coming out just behind the trochanter.

The point of the second needle is entered an inch below the level of the groin internal to the saphenous opening, and, passing through the adductors, comes out about an inch and a half in front of the tuber ischii. No vessels are endangered by these needles. The points are protected by corks, to prevent injury to the operator's hands.

A piece of strong white rubber tube half an inch in diameter, and long enough when tightened in position to go five or six times around the thigh, is now wound very tightly around and above the fixation needles, and tied.

The amputation is then carried out by means of the circular method. This method must of course be credited with the objections which have been urged against the elastic tourniquet. If the after-oozing be taken into account, operations conducted as above described cannot be regarded as "bloodless."

Precautions against Shock.—Every provision must be taken against shock. The limbs should be well wrapped up, the body enveloped in a blanket, and the head kept low. A stimulant may be given before the operation, and means should be at hand to administer brandy by enema or subcutaneous injection if required.

Methods of Operating.—The different methods advised by different surgeons for amputating at the hip-joint are exceedingly numerous. Farabeuf gives figures of no less than twenty-five different procedures, and, if each operation were to be named after the surgeon designing it, it would be necessary to describe some forty methods of disarticulation at the hip.

Many of these operations have long since been abandoned, and many differ from one another but in very trifling particulars.

In the account which follows it is only possible to deal

with certain typical methods without attempting to pursue the individual modifications of particular surgeons.

The following modes of performing this amputation will be described—

1. Disarticulation through an external racket incision.
2. Disarticulation through an anterior racket incision.
3. Disarticulation by antero-posterior flaps (transfixion).
4. Guthrie's operation.

1. Disarticulation through an External Racket Incision.—Under this title may be grouped the modified oval method with the summit of the incision on the outer side, the "raquette à queue trochantérienne," and the amputation by combined circular and vertical incisions (the vertical cut being external). These are the operations associated with the names of Ravaton, Kerr, Foullioy, Malgaigne, Cornuau, Scoutteten, Furneaux Jordan, Lister, Esmarch, and others.

Instruments.—The elastic tourniquet already described; a stout amputating-knife with a blade some six inches in length, and with not too fine a point; a large stout scalpel or resection knife; an amputating-saw; lion forceps if the bone is to be divided (*see* Esmarch's operation, page 535); artery forceps; pressure forceps; dissecting forceps; scissors, long needles, etc. If the operation is to be subperiosteal, a periosteal elevator or rugine is required.

Position.—The body is drawn down until the pelvis rests upon the extreme lower edge of the table. The sound limb is secured out of the way. The patient is turned sufficiently over on the sound side to expose the postero-external aspect of the limb to be removed. Some care has to be taken to prevent the patient from slipping entirely off the table. The surgeon stands on the outer side of the thigh—in the case of both the right and the left extremities—and faces the patient.

In the case of the left limb it may be sometimes more convenient to stand on the inner side of the thigh, between the limbs.

The assistant standing above the surgeon attends to the tourniquet and supports the flap during the ligaturing of the

vessels after the tourniquet has been removed. Another assistant manipulates the limb, while a third, standing opposite to the surgeon, attends to the sponging and assists in the disarticulation, in the fashioning of the flaps, and in securing the vessels.

The Operation.—1. The limb being adducted and a little flexed and rotated in, the knife is entered about two inches above the upper edge of the great trochanter, and is carried vertically down the limb along the posterior border of the trochanter for about seven inches. The knife is now drawn across the limb in front and behind in the form of two crescentic incisions, which meet on the inner side of the thigh some little way below the termination of the vertical incision, and some inches below the genito-crural angle. The whole of this extensive cut should at first involve only the skin and the subcutaneous tissues. At the outer aspect of the limb the incision forms a large inverted Y (Fig. 145, C). While the oblique incision is being made, the assistant may rotate the thigh a little so as to make the tissues meet the surgeon's knife.

2. The surgeon now turns to the oblique incision encircling the thigh, and separates the skin and subcutaneous tissues all round until these parts have been raised to the extent of about two inches.

This is effected precisely as in the ordinary circular operation, the limb being rotated as required.

3. The thigh being now again adducted, rotated in and a little flexed, the knife is carried well down to the femur along the whole length of the vertical incision.

The muscles attached to the great trochanter must next be divided close to the bone. The anterior, superior, and posterior borders of the trochanter should be cleared in order. The first muscle to be divided is the gluteus medius, attached to the outer surface of the process. The obturator externus tendon is apt to escape division as it dips into the digital fossa. In clearing the process the limb must be kept extremely adducted and well rotated in. A short stout knife—such as is used in Syme's amputation or in resection operations—is very convenient at this stage. The knife must be carried vigorously down to the bone.

The upper part of the shaft of the femur is now cleared as far as the vertical incision extends. The soft parts must be liberally cut, care being taken that the femoral and profunda arteries are not encroached upon.

In this step the insertions of the gluteus maximus, quadratus femoris, psoas, iliacus, pectineus and upper adductor fibres are divided, together with the superior portions of the triceps femoris. The surgeon is aided by an assistant, who draws the divided soft parts away so as to well expose the bone.

4. The bone has now to be disarticulated. The capsule may be divided transversely at its upper and posterior parts while the limb is in the position of extreme adduction. The anterior part of the capsule can be severed while the thigh is a little flexed.

The limb is now rotated outwards to its utmost, the joint opened, and the round ligament cut.

Everything about the upper end of the femur should now be free and ready for the final sweep of the knife.

Up to this point no vessels of any magnitude have been divided, the chief arteries concerned being the internal circumflex, some branches of the external circumflex and of the sciatic, and a few muscular vessels.

5. Nothing now remains but to cut the muscles upon the inner side of the limb by a vigorous circular sweep of the knife at the level of the already retracted skin. A few touches of the blade, and the limb is removed.

The great vessels are at once secured.

If the operation is to be "*subperiosteal*," the femur is stripped of periosteum by means of the elevator, the muscles being, so far as is possible, detached with it. This separation cannot be followed further than the base of the femoral neck, and involves a considerable expenditure of time. Along the linea aspera the detachment of the periosteum is exceedingly difficult. The value of this modification of the more ready method is discussed later.

Hæmorrhage.—In securing the bleeding points the assistant holds up the anterior part of the flap, so as to well expose the whole wound-surface. Care must be taken that the tourniquet does not slip when the limb is removed.

The great vessels are found severed on the anterior face

of the wound, close to the divided rectus, sartorius, and adductor longus muscles.

The vessels are placed one behind the other in the following order, from before backwards :—The femoral artery, the femoral vein, the profunda vein, the profunda artery.

The first vessel to be sought for after the main trunks are ligatured is the internal circumflex. It will be found divided in the tissues about the inner and posterior side of the acetabulum. The branches of this artery often give much trouble. The descending branch of the external circumflex is found cut close to the inner edge of the vastus externus. The transverse branch of that artery will also probably require a ligature.

In the posterior segment of the wound the comes nervi ischiadici is early recognised, and will require ligature.

Bleeding will occur from other branches of the sciatic artery, and from many muscular branches distributed about the surface of the wound.

Varieties of the Operation.—The first operation designed for the removal of the lower limb at the hip-joint was in all essential points identical with that just described. The surgeon was Ravaton, the date 1743.

The amputation also performed by Kerr, of Northampton, in 1778, was practically upon the same lines.

Kerr's external incision was in the form of an inverted V, and not of an inverted Y, as in the procedure just detailed.

Foullioy employed the external racket incision in 1841, having first ligatured the common femoral at the fold of the groin.

Malgaigne's operation (*en raquette*) was like the present procedure, except that the vertical incision was shorter, and the circular incision, therefore, more oblique.

The oval operations of Cornuau, Scoutteten, Günther, and others may be placed in the present category, and attention may be drawn to the close resemblance of this procedure to the amputation devised by Guthrie (page 541).

The following methods require more extended notice :—

(*a*) *Lister's.*—The above description of disarticulation at the hip is founded upon the sketch of an operation given by Sir Joseph Lister (" Holmes' System of Surgery," vol. iii., page 721).

Lister made the external incision eight inches in length (for an adult), and divided the soft parts around the inner side of the limb before the femur was cleared. The disarticulation of the bone was the last step of the operation. He furnished no directions for the precise performance of the operation, and founded its principles upon the procedure of Furneaux Jordan.

(*b*) *Furneaux Jordan's.*—Mr. Jordan ("Surgical Enquiries," second ed., page 303) gives the following description of his operation:—"A straight incision was made, and the trochanters and upper part of the shaft were freed from their muscular attachments, after which the capsule was opened. Next, the shaft was cleared downwards from all its attachments for a considerable distance, and then a few free sawing movements, with a long-bladed knife, through the thigh, from which the bone had been removed, ended the operation. The integuments were simply drawn upwards, and the soft parts were cut straight through. No bone being left, the muscles quickly retracted, and were easily covered by the skin. Very little blood was lost. . . . The principle of the operation may be thus described:—First enucleate the bone, then cut through the limb at any desired spot—the middle of the thigh, or below, or even near the knee."

Fig. 147.—FURNEAUX JORDAN'S AMPUTATION AT THE HIP-JOINT ("Surgical Enquiries," Plate X., page 288). The shaded part represents the area traversed by the knife; the dotted lines the incision.

It is evident from this description, and from the diagram of the operation given by Mr. Jordan (*see* Fig. 147), that his disarticulation differs very considerably from the procedures associated with his name by more than one writer.

(*c*) *Esmarch's.*—This method is identical with that described by Veitch, Lacauchie, Volkmann, and others.

Mr. Barker ("Manual of Surgical Operations," 1887) gives the following account of Esmarch's operation, in favour of which he speaks:—

"By a single, strong, muscular sweep of the knife five inches below the tip of the trochanter, all the soft parts of the thigh

are divided completely to the bone, and the latter is at once sawn across.

"The vessels are then ligatured.

"The bone is now seized in a lion forceps and steadied, while a second incision is made, commencing two inches above the tip of the trochanter, and carried down along the latter, to terminate in the first circular cut. The two borders of this incision being held apart by an assistant, the bone is cleared of the soft parts by the use of an elevator inserted under the periosteum, and by the knife where the muscle-insertions are too firm for the latter. When the capsule is reached it is divided, and the head is dislocated in the usual way."

2. **Disarticulation through an Anterior Racket Incision.** This method is also known as the anterior oval method.

It is founded upon the operations performed by Larrey in 1793, by Sir Astley Cooper in 1824, by Roser in 1856, and later by Verneuil. In the account of the operation, the admirable description of Farabeuf is followed.

The same *instruments* are required as are used in the previous operation. In addition to those mentioned, an aneurysm needle and a small scalpel will be needed. Retractors are occasionally employed.

The *position* of the surgeon and of his assistants is the same. The patient is so placed that the pelvis rests upon the extreme end of the table, and the trunk evenly upon the back.

The Operation.—1. No tourniquet is applied. The incision is commenced at the centre of Poupart's ligament, and is carried downward along the course of the femoral vessels for about three inches. It is then made to curve inwards so as to cross the adductors about four inches below the genito-crural fold. The knife then sweeps over the posterior aspect of the thigh, crosses the outer side of the limb a little way below the base of the great trochanter, and is carried obliquely across the anterior aspect of the thigh to meet the vertical incision about two inches below its point of commencement (Fig. 148).

This incision concerns at first only the skin and the subcutaneous tissue. It cannot be made with one sweep of

the knife, and the limb must be so held and so rotated as to make the tissues meet the knife.

2. The femoral sheath is now exposed at the upper part of the incision, and the vessels are laid bare by dissection. The common femoral artery is ligatured in two places close together, and is divided between the ligatures. The femoral vein is secured in the same manner, and then cut across at the same level as the artery.

3. The skin is freed all round the whole length of the incision, and is allowed to retract a little. The integuments, however, are not especially dissected up.

4. The stout scalpel is now taken, and is carried through the muscles in the outer flap. In this way are divided the sartorius, the rectus, and the tensor vaginæ femoris. The retraction of these muscles will expose the external circumflex artery, which is secured between two ligatures and divided

Fig. 148.—DISARTICULATION AT THE HIP-JOINT BY AN ANTERIOR RACKET INCISION.

Carry the knife backwards, rotate the limb in, and divide the insertion of the gluteus maximus. Rotate the limb out and divide the psoas muscle. At this point the internal circumflex artery is exposed, secured, and divided. Retractors are of use at this stage of the operation.

5. The muscles in the inner flap are now cut at the level of the retracted skin. These include the pectineus, the gracilis, and the superficial adductors. Any divided vessels are secured.

6. Adduct the thigh, and rotate it inwards so as to expose the great trochanter. Divide the insertions of the muscles attached to this process, notably the gluteus minimus and medius.

7. Abduct the limb and rotate it out. Incise the capsule transversely. Disarticulate. Divide the round ligament and

also the obturator externus tendon, if it has up to the present escaped division.

8. The limb being still more rotated outwards, the head of the femur is dragged forward, and the longer knife being passed behind the bone, all the soft parts at the posterior aspect of the limb are divided with one sweep of the blade at the level of the retracted skin. These tissues will include the hamstrings, the great sciatic nerve, and the undivided parts of the adductors, principally represented by the adductor magnus.

When the wound is approximated, there should be no strain upon the sutures, which are deeply applied.

Hæmorrhage.—It is a feature of this operation that the vessels are ligatured as they are exposed, the surgeon dealing with the hæmorrhage according to the method adopted during the removal of a large tumour. In my experience of this operation the loss of blood has been quite insignificant.

3. **Disarticulation by Antero-Posterior Flaps (Transfixion).**

This operation was at one time very extensively practised in England. The method is frequently known as Liston's operation. It has been very well described by Fergusson, and has been associated with the names of many French surgeons.

The great feature of the operation consists in the rapidity with which it can be performed. Fergusson states that the procedure can be completed (so far as the use of the knife is concerned) in from twelve to twenty seconds.

This was a matter of no little moment before the days of ether and chloroform.

The anterior flap is long and U-shaped. The posterior flap is shorter, and is more squarely cut.

No tourniquet of any kind is employed. Even the elastic band would be in the way, and would probably slip during the somewhat vigorous movements to which the limb is subjected. The main vessels are secured in the flap itself by the fingers of an assistant, who compresses them during the actual cutting of the flap.

Instruments. — A pointed amputating-knife, having a length equal to one and a half times the diameter of the limb

at the level of the hip. Artery forceps. Ten or fifteen pressure forceps. Scissors, needles, etc.

Position.—The patient is supine, and the buttocks rest upon the extreme edge of the table. The sound limb is secured out of the way. The surgeon stands to the outer side of the limb in the case of both the right and the left extremities. One assistant stands above the operator. His duty is to attend to the anterior flap, to compress the main vessels as the flap is being cut, and to hold it out of the way during the disarticulation. A second assistant stands opposite to the surgeon to assist generally, and to seize any bleeding points as soon as the limb is separated. A third helper may stand near the patient's shoulders (on the opposite side), to steady the pelvis and prevent the body from slipping off the table. The fourth assistant manipulates the limb. This office is of exceeding importance. The rapidity with which the disarticulation can be effected depends largely upon the smartness of this assistant.

The limb is made to assume a different position at each step of the operation.

1. The limb is a little flexed and a little abducted. The knife is entered midway between the anterior superior iliac spine and the top of the great trochanter, is thrust through the limb parallel with Poupart's ligament, and is brought out at the inner side of the thigh behind the adductor longus, about one inch in front and one inch below the tuber ischii, and some three inches from the anus.

The knife should graze the head of the femur in its passage, and just open the hip capsule. It is passed, therefore, as deeply as possible.

If reasonable care be not taken, the knife may slice the femoral vessels, or may be arrested by the femur, or may enter the thyroid foramen, or may have its point driven into the testicle or the thigh of the opposite side.

The surgeon now cuts, by a sawing movement of the knife, a U-shaped anterior flap some eight inches in length.

This flap will end about the junction of the upper with the middle thirds of the thigh (Fig. 146, B). It should include as much of the soft parts as possible.

It will be noticed that the knife is placed obliquely at the

commencement of the cutting of the flap, and that it becomes transverse at the termination. More tissue has to be divided on the outer than on the inner side of the limb. If the flap be carelessly cut, it is apt to be too pointed at its extremity.

As the knife is carried downwards, the first assistant slips his fingers under the cut surface of the flap and compresses the main vessels against his thumbs, which are placed upon the skin. It thus happens that before the femoral is divided at the end of the flap the upper part of the trunk is well secured.

As soon as the flap is made this assistant draws it upwards out of the surgeon's way, while he still grasps the great vessels.

2. The limb is straightened and is fully extended, *i.e.*, the knee is depressed. The surgeon cuts open the capsule.

The thigh is now rotated outwards. The head slips out of the acetabulum, and the round ligament is divided.

The thigh, still extended, is now rapidly adducted and rotated inwards, and the muscles about the great trochanter are cut.

The disarticulation is complete, and nothing remains but to cut the posterior flap.

3. The whole thigh is now lifted directly up in such a way that the free end of the femur is dragged away from the posterior tissues and is forced forwards.

The surgeon passes his knife behind the femoral head and the great trochanter, and, cutting downwards, forms the posterior flap.

This flap is shorter than the anterior, and the skin is divided about the level of the gluteal fold (Fig. 146, B).

The clearing of the great trochanter is perhaps the most difficult part of the operation. If not well done, a pocket is left in the flap at the site of that process.

Hæmorrhage.—The sciatic artery and branches of the gluteal in the posterior flap should first be secured; then the internal circumflex, close to the inner side of the acetabulum. The superficial femoral is divided near to the free extremity of the anterior flap. The profunda is usually found severed about the middle of the cut surface of the flap. In the outer part of

the same flap the external circumflex will be found and will require a ligature.

The femoral and profunda veins should be ligatured.

Varieties of the Operation.—Some surgeons have made an anterior flap only, cutting the soft parts at the back of the limb by a single sweep of the knife at right angles to the axis of the femur.

The anterior and posterior flaps have been made of the same length, *i.e.*, about five inches.

Fergusson made the anterior flap four inches in length and the posterior "somewhat longer."

Béclard cut the posterior flap first.

4. **Guthrie's Operation.**

This is the best type of operation by flaps cut from without inwards. The flaps are short and oblique, and are placed antero-posteriorly.

Instruments.—The elastic tourniquet is applied in the manner already described. A stout knife with a blade five inches in length; artery forceps; ten or fifteen pressure forceps; scissors, etc.

Position.—The position of the patient and of the surgeon and his assistants is the same as in operation No. 1 (page 531). It is more convenient for the operator to stand on the right-hand side of either limb.

The Operation.—The following is Guthrie's description ("Commentaries," 5th ed., 1853, page 76):—"The surgeon commences his first incision some three or four inches directly below the anterior spinous process of the ilium, carries it across the thigh through the integuments, inwards and backwards in an oblique direction, at an equal distance from the tuberosity of the ischium to nearly opposite the spot where the incision commenced. The end of this incision is then to be carried upwards with a gentle curve behind the trochanter, until it meets with the commencement of the first, the second incision being about or rather less than one-third the length of the first.

"The integuments, including the fascia, being retracted, the three gluteal muscles are to be cut through to the bone. The knife being then placed close to the retracted integuments, cuts steadily through everything on the anterior part and

inside of the thigh. The femoral or other large artery may then be drawn out and tied.

"The capsular ligament being well opened, and the ligamentum teres divided, the knife should be passed behind the head of the bone thus dislocated, and made to cut its way out, care being taken not to have too large a quantity of muscle on the under part, or the integuments will not cover the wound."

Fig. 149.—LISFRANC'S DISARTICULATION AT THE HIP BY INTERNAL AND EXTERNAL FLAPS.

5. **Other Methods of Disarticulation.** — Of the many other procedures not here described it is necessary only to allude to the amputations by *lateral flaps*.

These operations are still advised by some surgeons in cases of limited injury of the front of the thigh, as in gunshot wound, and in cases where a growth projects towards the anterior part of the limb. Very unwieldy stumps are left, and these methods have little or nothing to recommend them.

Figure 149 shows the incisions in *Lisfranc's method*. The flaps are cut by transfixion, the outer one being made first. After disarticulation has been effected the inner flap is cut. The vessels are ligatured as exposed. Each flap is about four inches in length, and are both very bulky.

The names of Larrey, Blandin, and Dupuytren are especially associated with these lateral-flap operations.

An excellent atlas of the various methods of amputating at the hip-joint is given by Farabeuf in his "Précis de Manuel Opératoire," 1885, page 634.

Comment.—1. Of these various operations those by the *racket method* may be considered to be the best.

Of the two methods involved, that which employs the anterior incision appears to me to be the more useful.

With no other form of disarticulating at the hip-

joint have I experienced such good results as with this method.

1. *The External Racket method* has the following points to recommend it:—

(*a*) The elastic tourniquet can be applied.

(*b*) The femur is approached through the least vascular part of the limb, and disarticulation may be effected before the main mass of the muscles of the thigh has been cut.

(*c*) The vessels of the part are divided transversely, and the main artery is severed late in the operation.

(*d*) Owing to the low position of the incision posteriorly, the branches of the gluteal and sciatic artery are but little interfered with, and the hæmorrhage from these vessels is comparatively trifling.

(*e*) The muscles are divided transversely, and the wound-surface therefore is small. The main muscular masses are divided low down, so that in a sense the limb is removed at a point further from the trunk than obtains in some of the other amputations, and shock is hereby diminished.

(*f*) An excellent stump is provided—*i.e.*, the ischium (the main point from which the future artificial limb will take its support) is well covered; the cicatrix is brought to the outer side of the limb, and is as far removed from the anus as possible; excellent drainage is provided for.

(*g*) The position of the vertical incision will permit of the hip being explored before operation, or of an excision being carried out should it be revealed that amputation is not necessary.

It is through this method that the *subperiosteal operation* can be best carried out.

This procedure involves a considerable expenditure of time, and even if the greatest care be taken it is scarcely possible to dissect up the whole of the periosteum from the exposed part of the femur.

In the most successful cases, as in Mr. Shuter's case of sub-periosteal amputation (*Clinical Soc. Trans.*, vol. xvi., page 80), a firm resisting cord of considerable size was found to occupy the centre of the stump, and to afford a common point of attachment to the muscles.

The patient was able to move the stump in all directions,

and to communicate those movements to an artificial limb. There is no evidence that any new bone was ever reproduced in the stump.

In Mr. Shuter's case the patient was at first able to wear the artificial limb for some hours nearly every day; but subsequently he was obliged to leave it off on account of its weight.

In *Furneaux Jordan's* operation the muscles may be divided still lower down, *i.e.*, about the middle of the thigh or near the knee.

Although the circular incision is made low down in the limb, and though a more slender segment of it is divided, it must be remembered that the deep vertical incision required to expose and resect the femur is proportionately increased in length. Bleeding from this vertical wound may be considerable, since several of the perforating arteries are cut.

Shock is no doubt much diminished by dividing the soft parts low down. With regard to the long, boneless stump left, Mr. Jordan writes:—"If the thigh were to remain a soft, pendulous mass, it would be a small price to pay for greater safety; but it is a remarkable circumstance that, as a rule, the muscles do not rest until the longest stump has become a short one."

Esmarch's method has the advantage of being rapid, and is moreover easily performed. The vessels are divided and secured at an early stage of the operation. This procedure is well adapted for the application of the subperiosteal method.

2. The disarticulation through an *anterior racket incision* has many of the advantages of the previous operation, and has other special claims of its own.

(*a*) All forms of elastic tourniquet can be dispensed with.

(*b*) The muscles are divided transversely, and the wound-surface is comparatively small.

(*c*) The division of the great mass of the muscles is made low down.

(*d*) The vessels in the posterior part of the limb are but little interfered with.

(*e*) The main vessels are ligatured early, and the other arteries are secured as they are cut.

(*f*) The hip-joint is directly exposed, and disarticulation is most easily effected.

Compared with the external racket method, the present procedure has these possible disadvantages :—

The femur is exposed through a muscular and vascular part of the thigh, and the vertical incision made is not quite so well adapted for a mere exploratory cut, nor for an excision wound should amputation be at the last moment abandoned.

The procedure is less rapidly effected, although the actual disarticulation is easier. This depends upon the fact that the smaller divided vessels are more easily dealt with after the limb has been removed than during the cutting of the flaps. The double ligaturing of the main vessels also involves time.

The stump is good, the ischium is well covered, the edges of the wound come easily together, but the flaps are not quite so well adapted to favour ready drainage.

3. The operation by *antero-posterior flaps cut by transfixion* has the advantage of great rapidity of execution. Before the days of chloroform, this was an advantage of the primest value.

In many instances at the present time, especially in cases of amputation for injury, rapidity of execution is of very considerable importance. It must be considered to what extent this single great advantage can overbalance the following grave disadvantages :—

(*a*) A tourniquet can only with difficulty be applied.

(*b*) The flaps cannot be very accurately cut.

(*c*) The muscles are divided obliquely, and the wound-surface is very considerable.

(*d*) The soft parts are divided high up, consequently there should be greater shock.

(*e*) The branches of the gluteal and sciatic arteries are so freely cut that copious hæmorrhage from the posterior flap is common.

(*f*) The stump does not provide a very excellent covering for the ischium. The cicatrix is exposed to pressure; the wound is carried very near to the anus, and efficient drainage is not provided unless drainage-tubes are employed.

The operation has advantages in military surgery, and in

some cases of accident, but it is scarcely applicable to disarticulation for disease.

4. *Guthrie's operation* is strongly recommended by several writers. Ashhurst ("Encyclopædia of Surgery") considers it to be, without reserve, the best mode of amputating at the hip-joint.

The operation occupies a position but little inferior to that held by the external and anterior racket methods.

The same advantages can be claimed for it as are claimed for the latter operation. The muscles are, however, not divided so transversely, and disarticulation is not quite so readily effected. The operation is, on the other hand, more rapidly performed, and the femur is exposed through a less fleshy and vascular part of the limb.

The operation is inferior to the external racquet method for reasons that need not be recapitulated.

An excellent stump results, the ischium is well covered, the wound is brought more to the outer side of the extremity, and is well adapted for efficient drainage. The cicatrix is small and protected from pressure.

AFTER-TREATMENT OF AMPUTATIONS AT THE HIP-JOINT.

After the operation all necessary means should be taken to prevent severe shock. The head should be kept low, the body be well covered with blankets and kept warm by hot bottles, and, if necessary, enemata of brandy may be administered.

By means of a suitable cradle the stump can be left uncovered, and the dressings be exposed to the air. The stump should be supported upon a firm pillow or cushion, care being taken that no pressure is exercised upon the wound.

It is not reasonable to suppose that the great wounds left by these operations will heal up throughout by first intention. There is always a considerable discharge of sero-sanguinolent matter from the large wound-surface. In the racquet operations, and in Guthrie's disarticulation, drainage may be secured by omitting a suture or so at the most dependent point of the wound. In the transfixion operation by antero-posterior flaps, a drainage-tube will most probably be required.

The weight of the flaps renders it important that the sutures should not be removed too soon, and after their removal it will, as a rule, be found necessary to support the flaps by strapping.

Care must be taken that the dressings are not soiled by urine or fæces, and that bed-sores do not form over the sacrum or the trochanter of the opposite side.

Part VI.

OPERATIONS ON THE BONES AND JOINTS.

CHAPTER I.

Osteotomy.

By osteotomy is understood the division of a bone in its continuity for the relief of deformities of various kinds.

The operation has been adopted in the treatment of such conditions as the deformity produced by mal-union after fracture, the curving of bones incident to rickets or extensive necrosis, osseous anchylosis of joints, genu valgum, and some other deviations.

Linear osteotomy implies the division of the bone in its continuity in a single transverse line, the subcutaneous method being carried out.

Cuneiform osteotomy is the term applied to the cutting-out of a wedge-shaped piece for the relief of such deformity as that represented by the curved tibia met with in rickets.

In both forms the operation may be performed by means of a saw, or a chisel, or an osteotome.

The earlier operations were performed for the relief of deformity following upon fracture, and the bone was divided through a large open wound.

Thus Lemercier, in 1815, sawed through the femur to correct the deformity due to mal-union of a fracture of that bone.

The first osteotomy, in the sense in which the term is now usually employed, was performed by Rhea Barton, an American surgeon, in 1826 (*North American Medical and Surgical Journal*, April, 1827). He divided the femur between

the two trochanters, to remedy a vicious anchylosis of the hip-joint. A saw was used, and a large skin-incision made. The osteotomy was linear.

Another American surgeon—Rodgers—is credited with having performed the first cuneiform osteotomy in 1830 (also for anchylosis at the hip).

A. Key performed in England a linear osteotomy—with a saw—for the treatment of an angular bend in the tibia following fracture (*Guy's Hospital Reports*, 1839, page 193).

Langenbeck carried out the first subcutaneous osteotomy in 1852-3 (*Deutsche Klinik*, 1854, No. 30).

Meyer, of Würzburg, appears to have performed the first osteotomy for rickety curvatures in 1851 (*Illustrirte Medizin. Zeit.*, 1852, pages 1 and 65).

Mr. Stromeyer Little claims to have performed the first subcutaneous osteotomy in England in 1868 ("In-Knee Distortion," 1882, page 149). The case was one of osseous union of the knee-joint. A chisel and mallet were employed.

Adams' operation upon the neck of the femur for bony anchylosis dates from 1869 ("A New Operation for Bony Anchylosis of the Hip-joint," 1871). Ogston's operation for genu valgum dates from May, 1876 (*Edinburgh Medical Journal*, March, 1877), and Macewen's osteotomy for that deformity was first carried out in 1877 (*Lancet*, March, 1877).

The Instruments employed.

The following are the instruments required in these operations:—(1) An ordinary scalpel; (2) chisels and osteotomes of various sizes; (3) mallet; (4) saws for subcutaneous division of bones; (5) sand bag; (6) blunt hooks.

The Chisels and Osteotomes employed are those introduced by Dr. Macewen. The chisel has the same form as the ordinary carpenter's chisel. It is square at the end, and has a very sharp edge. It should be made of the finest steel, and be very carefully tempered. The part of the instrument near the cutting edge is alone raised to a great degree of hardness; the rest of the blade is kept softer, so that there shall be no danger of its snapping. The edge is bevelled on one side only, according to the ordinary pattern, and the thickness of the blade at the base of the bevel is about one-

twelfth of an inch (Fig. 150). Chisels with unduly thick blades are clumsy, and are apt to splinter the bone.

It is desirable that the blade and the handle be made of one piece of metal; that the handle be octagonal, for convenience of holding; and that the head be rounded, smooth, and projecting, to receive the blows of the mallet (Fig. 151).

Fig. 150.
SECTION OF CHISEL. SECTION OF OSTEOTOME.
(Both natural size.)

Macewen's osteotome has a wedge-shaped extremity, and has the outline, as seen sideways, of an attenuated double-inclined plane (Figs. 150 and 151). It is square at the end, has a sharp edge, and is tempered in the same way as the chisel. The precise fashioning of the blade is shown in the full-sized figure (Fig. 150). The handle and the extremity of the instrument are the same as the chisel. Indeed, these two instruments differ only in the manner in which their cutting extremities are bevelled.

They should present various widths of blade, according to the size of the bone to be divided. The most convenient sizes are represented by three instruments, the smallest of which is one-third of an inch wide in the blade and the largest from half an inch to two-thirds of an inch in width. Upon the side of the osteotome a half-inch scale is marked, so that the depth to which the instrument has passed may be noted.

The chisel is used only for paring, shaving, and cutting out wedges of bone, as in cuneiform osteotomy.

The osteotome is employed only for making simple incisions or wedge-shaped openings, but without removal of bone. The chisel, like the ordinary carpenter's chisel, is apt to go awry if a straight section be attempted.

It is well that new instruments should be tried upon the bones of animals before being used in operating upon the living subject, if there be any doubt as to their strength.

In one case, when dividing the femur for deformity following a mal-united fracture, I was horrified to find on removing the osteotome that a large angular piece had been broken from the cutting edge. I was unable to remove the

fragment, but the bone united without complication, and no inconvenience followed upon the retention of the piece of steel, which was no doubt buried in the callus.

The *Mallet* is made of some hard wood, such as *lignum vitæ*. The leaden mallets used by many French surgeons have little to recommend them.

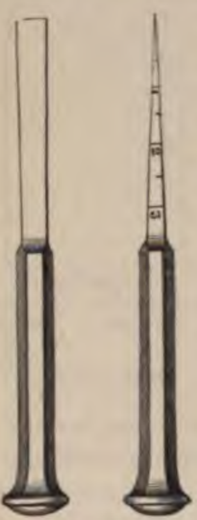

Fig. 151.—MACEWEN'S OSTEOTOME.

The *Saws* used for the subcutaneous division of bone are founded upon Adams' saw. The blade is very slender, and the serrated edge is of limited extent (Fig. 152). Many saws have been introduced, but they differ little from Adams' instrument, except in the shape of the handle or in the inclination of the blade to the handle. Trocar saws and concealed saws are ingenious, but are of no especial practical value.

The *Sand Bag* or *Sand Pillow* is used for the purpose of fixing or imbedding the limb during the process of dividing the bone with the osteotome.

The sand pillow used by Dr. Macewen measures 18 inches by 12 inches. The case is filled with sand just sufficient to enable it to be shifted from one part of the bag to another without leaving any portion empty—a moderate fulness without distension. "The sand is moistened just before the operation, to prevent the escape of dust and to produce greater cohesion between its particles, so that it will more readily retain the form or mould imparted to it. It is then covered with a sheet of jaconet or other waterproof material, and laid on a table" (*Macewen*).

THE OPERATION.

1. Linear Osteotomy with the Osteotome.

The operation cannot be better described than in the terms employed by its author, Dr. Macewen:—

"The patient ought to be placed fully under the influence of an anæsthetic, and this should be maintained during the

performance of the operation and until the limb is securely fixed in splints. After the patient is fully anæsthetised, the limb is rendered bloodless . . . and is placed on a sand pillow. . . . The limb is then imbedded in the pillow in the manner suitable for the particular operation.

"In order to introduce either the saw or the osteotome, a wound in the soft parts must be made. This wound ought to be a sharp, clean, single incision, produced by one stroke of the instrument whenever this is practicable. Dissection ought to be avoided, the situation in which the incision is to be made being chosen so as to get to the bone as directly as possible. The direction of the incision should be in a line with that of the muscular fibres about to be penetrated. The situation of the wound in the soft parts ought to be selected

Fig. 152.—ADAMS' SAW.

so as to avoid cutting, not only the larger vessels, but also the smaller ones, when this can be done.

"As to the extent of the incision, this depends greatly on the surgeon, whether he wishes to see what he is doing, or whether he can trust to the tactile sensations conveyed through the instrument to his hand as a sufficient guide. If the latter, the wound need only be large enough to admit the osteotome; if the former, it would require to be a couple or more inches in length, according to the depth of the tissues. When a surgeon commences to practise osteotomy, it would be well for him to make a large incision, one sufficient to enable him to examine the bone with the finger, or even to see the bone. In this way he performs his operation with more confidence, and the extent of his incision is an element of safety, inasmuch as it provides a ready exit for discharge—blood or serum—which otherwise might be pent up in the parts, causing distension. After he has gained a little more experience, the osteotome may be used as a probe (the saw

will never answer this purpose), the sensations conveyed through the instrument being sufficient to enable the operator to ascertain all that can be known by the introduction of the finger. When the operator has reached this stage, all that is necessary is to make an incision which will enable the osteotome to reach the bone—from half an inch to an inch long, according to the breadth of the blade. By operating in this way the tissues are much less disturbed, there is less effusion of blood or serum, and much less need of drainage.

"When small wounds are made, the knife ought to remain *in situ* until the saw or the osteotome is introduced by the side of it to the bone, the knife acting as a guide. When the osteotome has reached the bone, it should be turned in the direction in which the osseous incision is to be made, care being taken while doing this not to denude the bone of periosteum.

"The osteotome ought to be used in such a way as to direct its cutting edge away from any important soft structures which it may be necessary to avoid. As the osteotome has blunt sides, it may be used to lever the soft tissues aside, keeping, meanwhile, the cutting edge of the instrument in close contact with the bone.

"After a little practice, the osteotome acts as a probe, and when once the tactile impressions conveyed through the instrument are cultivated, it becomes a delicate indicator of the state of the bone, the precise relation of the osteotome to it, and the extent of the osseous incision. But when the osteotome has been imbedded in the bone for an inch or two, its delicacy of touch is lost, and it no longer remains a precise indicator of what is in contact with its cutting edge. This is due to the manner in which the sides of the instrument are pressed on and caught by the bone, the amount of lateral pressure varying according to the amount of the osseous tissue through which the instrument passes.

"This may be easily rectified by introducing a finer instrument by the side of the thicker one first used, and withdrawing the latter. The finer instrument is then placed in the osseous groove made by the thick one; but, being a more attenuated wedge, its sides are not pressed on, so that it acts

as an indicator of the kind of tissue in immediate contact with its cutting edge. This can be repeated in a thick bone by the substitution of a third instrument of still greater acuteness.

"When using the osteotome, it ought to be grasped firmly in the left hand, steadied by the inner border resting on the patient's limb. The surgeon ought to cut to, instead of from, himself; thus, if the surgeon is operating on the inner side of the left limb, he ought to stand on the left side of the patient, and cut towards himself.

"If the surgeon, instead of following this instruction, should hold the osteotome loosely, a slightly uneven blow with the mallet would outweigh his grip, and might cause the instrument to slide along the surface of the bone, peeling the periosteum, or causing a more unpleasant accident, such as penetration of an artery.

"When the chisel is placed in position, the mallet may then be brought into requisition, being used by the right hand. When the external shell of bone is felt to have given way, it is not advisable to attempt to complete at once this particular portion of the section, because the instrument is apt to be caught. In order to avoid the impaction, the entire superficial portion of the section ought to be completed in the first instance, so as to permit a little movement of the instrument in the direction of its breadth; and by making a series of such movements, after each impulse given by the mallet, there can be no fixity. The osteotome ought not to be pressed against the bone transversely to its breadth, as it is possible that it may be broken or twisted by so doing. The bone itself may be splintered longitudinally by such pressure. In no instance should the osteotome or chisel have a breadth greater than the diameter of the bone about to be cut, otherwise the soft structures at either side are apt to be injured." (*See* also the account of Macewen's operation for genu valgum, page 567.)

Comment.—This operation should never be attempted until the surgeon has gained quite an extensive experience by operating upon animals' bones, which should be quite fresh, and be imbedded upon a sand-bag, and by performing osteotomies upon the cadaver. The manual dexterity

required is of a special kind, and can only be developed by practice. The osteotome and mallet are powerful instruments, which demand the greatest precision and nicety in their handling, and which become most dangerous implements when employed by those who have taken no trouble to acquire familiarity with their use.

After such a series of experiments as has been named, the operator can divide a bone with neatness and accuracy; he has learnt precisely what amount of force to use and how to use it, and he can follow the progress of the buried chisel as easily as if the instrument and the bone were beneath his eye.

There should be no need, therefore, to make a larger incision in the soft parts than is required for the mere introduction of the osteotome or chisel, and a surgeon would do well not to operate upon the living subject until, by careful practice, he has acquired confidence in himself and in his ability to operate through a small incision.

In my opinion no tourniquet or elastic band should be employed to render the limb bloodless. While Esmarch's elastic compressor obviously prevents any bleeding during the actual operation, it is certain that it induces a greater degree of oozing when the bandage is removed (page 279). There is no operation area to be obscured by blood. The surgeon guides his instrument by his touch and not by his eyes. If an artery should be divided by accident, the sooner the injury is discovered the better. The Esmarch's band merely postpones the discovery until a larger and deeper wound has probably been made, and is of no assistance in lessening the severity of the lesion.

Other things being equal, I should say that in osteotomy more blood will be lost by the "bloodless method" than by an operation carried out in a limb the circulation of which has been in no way restrained.

It should be a rule that the incision in the soft parts should be so placed as to reach the bone by the shortest and safest route and in the most convenient place, and it should be in a line with the section it is proposed to make in the bone. Dr. Macewen makes the incision in the soft parts at right angles to the line of the incision on the bone, and

introducing the osteotome, turns it into place after introduction. This complicates matters a little, and although it is quite in accord with the principles of the subcutaneous method, the measure is—with modern antiseptic precautions—unnecessary.

The osteotome should, of course, always be so applied as to cut from and not towards the main artery, should it be near the line of section. In one or two positions this is not quite possible, *e.g.*, so far as concerns the upper tuberosity of the tibia and the popliteal artery.

When once the osteotome has cut into the bone, care should be taken that the cut be not lost. If the blade slip or be removed, much time may be wasted and no little damage done in attempting to find again the original cleft in the bone.

2. Linear Osteotomy with the Saw.

This operation differs but little from the last, except in the main element that the saw is used in the place of the chisel.

The same care is taken that the procedure is subcutaneous, and that as little damage as possible is done to the soft parts.

The best situation for dividing the bone having been selected, and the part being firmly held, a narrow-bladed knife is passed through the skin down to the bone. The tissues are so divided that the bone is laid bare along the line which the saw must travel. The knife employed should be shaped like a tenotome, must be long enough to cover the whole distance in the case of a deep-seated bone, and the cutting edge should not extend along the whole length of the blade. While the knife is being manipulated in the depths of the limb, the non-cutting part of the blade should then be in contact with the skin. The knife is employed to make a space for the passage of the saw, and the deep incision should not be so incomplete that the saw has to be forced through the tissues. The skin wound should be as small as possible, and should be made at right angles to the surface to be sawn.

Before the tenotome is quite withdrawn the saw should be carefully introduced by the side of it, so as to reach the part of the bone which has been incised. When the saw is

in position, the knife is withdrawn. A suitable pattern of the Adams' saw is employed.

The saw must be used with short strokes, and care must be taken that its tip is not ruthlessly thrust into the tissues upon the opposite side of the bone.

Especial care should be taken to see that the saw is perfectly clean, and that the composition with which it has been brightened has been brushed out from among the teeth.

Comparison of the Two Methods.

Of these two methods, that of dividing the bone by means of an osteotome is undoubtedly the better. The saw is easier to use, and carries with it the comparative safety which belongs to a blunt instrument. Its use, however, leaves a quantity of bone *débris* in the depths of the wound, which, while it often appears to be harmless, may yet act as irritant foreign matter and excite suppuration. There is considerable risk of lacerating the soft parts around the bone with the tip of the saw, and also with its blade as the section is being completed. As Dr. Macewen points out, the pump-like movement of the saw is apt to introduce air into the wound, and to do away with the subcutaneous principle.

The osteotomė, or chisel, on the other hand, is somewhat difficult to use, and while perfectly safe in the hands of an experienced operator, is a dangerous weapon when used by a beginner. The parts are divided by a clean, fine, simple cut. The instrument is not moved to and fro in the line of the wound. There is no bone *débris*, and there should be no laceration of soft parts. The instrument is powerful and of wide application.

3. **Cuneiform Osteotomy.**

In this form of the operation a cuneiform or wedge-shaped piece of bone is removed to remedy an abnormal curve or angular deformity. It has been applied in the treatment of the curved femora and tibiæ resulting from rickets, in some cases of bony anchylosis at an unusual angle, and in a few examples of angular deformity produced by mal-union after fracture.

The exact size and shape of the wedge must be carefully determined, and must obviously depend upon the position and extent of the deformity.

In general terms, it may be said that the sides of the wedge should be at right angles to the axis of the bone respectively above and below the seat of the operation (Figs. 153 and 160). In actual practice, however, so large a wedge-shaped piece of bone is very seldom removed. If the curvature in the bone be not extreme many surgeons content themselves with a mere linear osteotomy, leaving a gap between the divided ends when the limb has been adjusted, which gap appears to fill up without complication (Fig. 159, c).

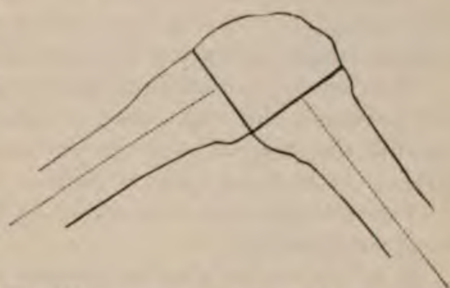

Fig. 153.—DIAGRAM TO SHOW THE LINES OF THE CHISEL CUTS IN CUNEIFORM OSTEOTOMY FOR ANGULAR DEFORMITY AFTER FRACTURE, ETC.

In the severer kinds of deformity a wedge may be removed much smaller than is necessary to entirely overcome the deviation, a gap of moderate size being left when the limb has been brought into its normal position upon a splint.

The wedge, moreover, need not extend through the entire thickness of the bone. It may involve possibly three-fourths of the diameter of the bone, the remaining fourth being bent or broken.

In performing this operation a chisel will be found in most instances to be more convenient than a saw.

In some forms of bony anchylosis of joints, however, the saw may prove to be the more suitable instrument, or both saw and chisel may be used together.

The incision in the soft parts must of necessity be comparatively large—as large at least as the base of the intended wedge. It need be no larger, since the skin can be displaced in one or other direction according to the position of the chisel.

As soon as the bone is exposed, the periosteum must be divided and carefully separated with the elevator.

In dividing the bone the chisel should be employed and not the osteotome.

The instrument must be so held that the straight edge is towards the bone to the left, and the bevelled edge towards the portion to be removed.

If a large wedge has to be removed, it should be dealt with in sections. A small wedge-shaped piece should first be taken out, and then thin slices of bone should be shaved from each side of the exposed bone until a cuneiform cavity of the desired size and shape has been produced.

If an attempt be made to remove a large wedge at once, it will be found that the chisel is apt to go awry, to incline towards the straight edge, and in consequence an uncertain division of the bony tissue is made.

There is apt to be free oozing as the cancellous tissue is being cut through.

It is not well to attempt to prise out the wedge of bone with the chisel. The bone so treated is apt to split, or the chisel may be broken. The wedge can be removed better with forceps aided by an elevator.

After the bone has been dealt with, the periosteal flaps may be brought together by a few fine catgut sutures. The skin wound should not be too completely closed, but room left for drainage.

A sponge dusted with iodoform, or a pad of Tillmann's dressing, forms the best dressing.

No especial observations need be added with reference to cuneiform osteotomy performed with the saw.

The After-treatment.—The after-treatment of osteotomy cases is very simple. The case is one of compound fracture made in the most favourable circumstances.

The limb must be put up in a suitable splint which will correct the deformity, keep the divided ends of the bones in close apposition, and maintain the limb at absolute rest. As many of the patients are children, the selection of a proper splint is a matter of moment.

The time during which the limb must be kept adjusted upon the splint will correspond to the time required for a fracture of the same bone to consolidate. Indeed, the after-treatment is essentially that observed in cases of fracture.

In the majority of instances no sutures are needed for the wound. They should be avoided whenever possible.

I have always dressed my osteotomy wounds with a large clean sponge well dusted with iodoform. This sponge is bandaged firmly over the wound with a flannel bandage. In the majority of cases this very simple dressing need not be removed until some weeks have elapsed and the union of the bone is advanced.

Results.—The results of osteotomy operations may be said to be in every way excellent. Since the introduction of the subcutaneous method, since the methods of operating have been more precise, and since the employment of antiseptic measures in the treatment of the wound has been introduced, the risk attending these operations has been reduced to an insignificant figure. Indeed, the commoner osteotomies may be said to be practically devoid of risk. Dr. Macewen alone has published a series of 330 cases operated on for various deformities of the lower limbs, and among this number there was no death as a result of the bone section.

CHAPTER II.

Osteotomy for Faulty Anchylosis of the Hip-Joint.

This measure is carried out in certain cases of rigid anchylosis of the hip-joint, resulting from disease, in which the limb has assumed a faulty position, and all milder methods of treatment have failed. In the most usual deformity the thigh is flexed, adducted, and a little rotated in. The object of the operation is to bring the limb straight. The possibility of securing a movable joint at the same time may or may not be contemplated by the operator.

A. **Through the Neck of the Femur.**

This operation may be performed either with the saw or with the osteotome.

Operation.—1. *With the Saw (Adams' Operation).*—This procedure is thus described by Mr. W. Adams:—

"The left thumb is placed firmly, so as to compress the soft tissues solidly against the bone, at a point situated at the centre of the top of the great trochanter and the breadth of one finger above it.

"At this point the narrow-bladed knife is pushed in till it reaches the neck of the femur, at a right angle across the front of which it is then carried (Fig. 154, A). The knife is then gently moved to cut a space for the easy insertion of the saw, which, traversing the course of the knife, reaches the front of the neck of the femur, and gradually cuts it completely through. The surgeon cuts until he feels that the saw is free of the bone, and moving in the soft tissues only behind the bone."

2. *With the Osteotome.*—The patient lies upon the sound hip, and the surgeon stands to the outer side of the limb. An assistant steadies the thigh and pelvis.

A longitudinal incision about three-fourths of an inch in length is made just above the great trochanter, and in the

axis of the neck of the bone. The knife is carried well down to the bone. The osteotome follows the knife, and on reaching the femur is turned on its axis so that its cutting edge is at right angles to the axis of the neck.

A few blows from the mallet will suffice to divide the bone.

B. **Through the Shaft of the Femur below the Trochanters.**

The operation most usually carried out in this situation is that known as Gant's. Mr. Gant performed the operation in 1872 (*Lancet*, Dec., 1872). Either the saw or the osteotome may be employed. The latter should be the instrument selected.

Operation. — The osteotomy is carried out precisely as in the procedure just described.

The incision is longitudinal, is placed over the outer aspect of the femur and about at the level of the lesser trochanter.

The osteotome is introduced, is turned upon its axis in the manner already described, and the bone is divided immediately below the lesser trochanter and in a line at right angles to the shaft of the femur (Fig. 154, B).

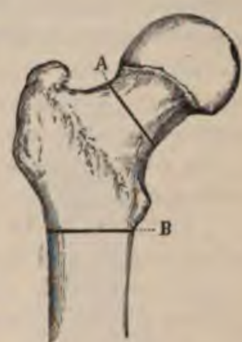

Fig. 154.—OSTEOTOMY FOR FAULTY ANCHYLOSIS OF THE HIP.

A, Intracapsular; B, Extracapsular.

Comment.—In these situations the bone should be divided completely. It should not be partially cut through and then fractured, lest dangerous splinters of bone be produced. The assistant therefore should be careful how he holds the limb, and how he brings pressure to bear upon the parts which are being divided.

Splinters of bone resulting from section of the neck of the femur have been driven into adjacent arteries, and serious bleeding has resulted (Jacobson's "Operations of Surgery," page 1388).

As to the instrument to be used, reasons have been already given (page 558) for preferring the osteotome to the saw, and to operations in this region the same criticisms apply.

In severe and old-standing cases the mere division of the bone may possibly not suffice to correct the deformity, and it may be necessary to cut contracted tendons or contracted bands of fascia. The tendons most usually in need of tenotomy are those of the adductor longus, rectus, and sartorius.

In the operations upon the neck of the bone it is assumed that the division takes place within the capsule.

Of the two methods described—viz., that of division of the neck, and that of division of the shaft—the latter may be said in general terms to be the better. It is certainly the simpler and the easier operation. It has been asserted that Gant's operation leads to more shortening, but the statement does not appear to be well founded, and shortening is largely a question of after-treatment.

In Adams' operation the saw is apt to travel beyond the neck and be carried through some part of the shaft.

"If the bone be dense," writes Jacobson, "from previous inflammation, and the section trenches upon the shaft instead of going through the neck only, the sawing may be very tedious. Thus I have twice seen cases in which this took over half an hour."

Adams' operation is only applicable to cases in which the neck of the femur has remained unaltered, *e.g.*, in anchylosis after rheumatic fever.

In many instances there is practically no neck to the bone, or there is an immense mass of thickened tissue in the position of the old capsule, or the head of the femur has been displaced upon the dorsum.

After division of the neck considerable deformity may still persist, owing to extreme contraction of the psoas and iliacus muscles.

Volkmann advised the removal of a cuneiform piece of bone from the shaft below the trochanters, as the best means of dealing with cases of anchylosis of the hip (*Centralblatt für Chirurgie*, No. 1, 1874), but linear osteotomy has been shown to be in every case sufficient.

CHAPTER III.

Osteotomy for Genu Valgum.

Anatomical Points.—In the severer forms of genu valgum —and it is in these only that osteotomy is practised—there is a great increase in the size and depth of the internal condyle. This is due—as has been shown by Mickulicz—to an increase in the diaphysis of the bone rather than in the epiphysis (Fig. 155).

The position and limits of the lower epiphysis of the femur are dealt with in the chapter on excision of the knee. It is only necessary here to repeat that the epiphyseal line is about on a level with the tubercle for the adductor magnus tendon. The trochlear surface of the femur belongs to the epiphysis.

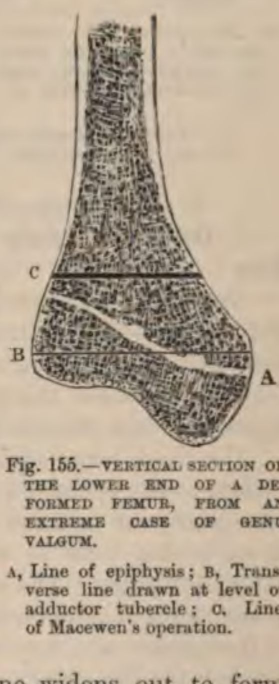

Fig. 155.—Vertical section of the lower end of a deformed femur, from an extreme case of genu valgum.

A, Line of epiphysis; B, Transverse line drawn at level of adductor tubercle; C, Line of Macewen's operation.

A transverse section of the femur about the epiphyseal line will show that the outer part of the bone is much more extensive than the inner part, and this disproportion is continued for some little distance upwards in the less expanded part of the bone (Fig. 156). The medullary canal ceases some way above the point at which the shaft of the bone widens out to form the condyloid extremity. Indeed, none of these operations concern the canal.

The synovial membrane of the knee-joint extends upwards as a large cul-de-sac above the patella and beneath the extensor tendon. This cul-de-sac is somewhat triangular, has

its base at the condyles and its narrowest part uppermost, and reaches a point an inch or more above the upper margin of the trochlear surface of the femur.

When the knee is bent, the cul-de-sac is drawn down.

Above the synovial pouch is a bursa, which lies upon the bone and measures about one inch vertically. This bursa communicates with the knee-joint in about seven cases out of ten.

Fig. 156.—TRANSVERSE SECTION OF THE FEMUR ABOUT THE LEVEL OF THE EPIPHYSEAL LINE, SHOWING THE TRIANGULAR OUTLINE OF THE BONE.

A, P, E, I, Anterior, posterior, external, and internal surfaces.

In certain of these operations the position of the anastomotica magna artery must be borne in mind.

The following *operations* will be described:—

1. Osteotomy of the shaft of the femur from the outer side.
2. Macewen's supra-condyloid operation.
3. Ogston's operation by dividing the internal condyle.

1. Osteotomy of the Shaft of the Femur from the Outer Side.

Operation.—The patient lies upon the back, with the knee flexed over a sand-bag, upon which the limb is made to rest securely. The surgeon should stand to the inner side of the limb, *i.e.*, between the patient's legs. An assistant standing opposite to him steadies the limb.

The thigh being adducted so as to well expose the outer surface to the operator (as he stands to the inner side of the knee-joint), an incision about one inch in length is carried down to the bone at a point about two inches above the external condyle. The incision is made upon the outer side of the thigh, is transverse—*i.e.*, at right angles to the long axis of the femur—and may be made in one cut. The knife passes through the ilio-tibial process of the fascia lata, and runs in front of the biceps muscle.

When the knife is withdrawn, the osteotome is inserted, and the limb—no longer adducted—is firmly planted upon the sand-bag. The osteotome is made to traverse the shaft transversely. As the outer part of the bone is here thicker

than the inner part, it will be found that when two-thirds of the shaft have been divided the bone can usually be readily fractured. It is essential that the division be extensive enough, and that no premature and violent attempts be made to complete the division of the bone.

Comment.—This operation is simple, although the position of the surgeon is a little inconvenient.

The bone is divided at a much narrower part than in the supra-condyloid operation next to be described; the osteotomy is therefore easier and more quickly performed.

There is no danger of the chisel wandering into the wide expanse of bone which makes up the external condyle.

The bone section is far removed from the epiphyseal line, and is also at a distance from the synovial sac of the knee-joint.

No blood-vessels of any importance come in the line of the incision.

2. **Macewen's Supra-condyloid Operation.**

Operation.—The patient lies upon the back, close to the edge of the table. Both hip and knee are flexed; the thigh is abducted and rests upon its outer side. The knee is well fixed upon the sand-pillow. The surgeon places himself upon the outer side of the limb. One assistant, standing upon the opposite side of the table to the operator, steadies the limb by the thigh, while a second assistant at the foot of the table takes hold of the upper part of the leg.

The following is Macewen's description (Heath's "Dictionary of Surgery," vol. ii., page 143):—

"A sharp-pointed scalpel is introduced on the *inside* of the thigh, at a point where the two following lines meet—one drawn transversely, a finger's-breadth above the superior tip of the *external* condyle, and a longitudinal one drawn half an inch in front of the adductor magnus tendon. The scalpel here penetrates at once to the bone, and a longitudinal incision (A, Fig. 157) is made, sufficient to admit the largest osteotome and the finger, should the surgeon deem it necessary. Before withdrawing the scalpel, the largest osteotome is slipped by its side until it reaches the bone.

"The scalpel is withdrawn, and the osteotome, which was introduced longitudinally, is now turned transversely in

the direction required for the osseous incision (B Fig. 157) In turning the osteotome, too much pressure must not be exerted, lest the periosteum be scraped off. It is then convenient to pass the edge of the osteotome over the bone until it reaches the posterior internal border, when the entire cutting edge of the osteotome is applied, and the instrument is made to penetrate from behind forwards, and towards the outer side.

Fig. 157. — MACEWEN'S OPERATION FOR GENU VALGUM.

A, Skin incision; B, Osteotome incision; C, Epiphyseal line; D, Inner condyle.

"After completing the incision in that direction, the osteotome is made to traverse the inner side of the bone, cutting it as it proceeds, until it has divided the uppermost part of the internal border, when it is directed from before backward towards the outer posterior angle of the femur.

"In cutting on these lines there is no fear of injuring the femoral artery. The bone may be divided without paying heed to this order of procedure, but it is better that the operator should have a definite plan in his mind, so that he may be certain as to what has been divided and what remains to be done. The writer is persuaded that accidents have happened by not paying heed to this. In using the osteotome, the left hand, in which it is grasped, ought to give, after each impulse supplied by the mallet, a slight movement to the blade—not transversely to its axis, but longitudinally—so as to prevent any disposition to fixity which it might assume.

"After the inner portion of the bone is divided, a finer instrument may be slipped over the first, which is then withdrawn; and even a third, if necessary, may take the place of the second when the outer portion of the bone comes to be divided. Whether one or more osteotomes be used depends much on the resistance met with. If the tissue is yielding, one may suffice; if hard or brittle, two or three will effect the division more easily and with less risk of breaking or splitting the bone longitudinally. In the adult the dense circum-

ferential layer of bone resists the entrance of the osteotome at the outset, but several strokes cause the instrument to penetrate this superficial dense portion, when it will pass easily through the cancellated tissue.

"After a little experience, the surgeon recognises, by touch and sound, when the osteotome meets the hard layer on the outer aspect of the bone. If it be considered desirable to notch or penetrate this outer dense part of the bone, in doing so the osteotome ought to be grasped firmly by the left hand, the inner border of the hand resting on the limb, so as to check instantly any impetus which may be considered too great. It is better to snap or bend this layer rather than cut it.

"When the instrument is to be altered in position, it ought not to be pulled out in the ordinary way, as it is then liable to be removed from the wound in the soft parts, as well as from the bone. Instead, let the left hand, with its inner border resting on the limb, grasp the instrument, while the thumb is pressed under the ridge afforded by the rounded head, and gently lever the osteotome outwards by an extension movement of the thumb. In this way the movement may be regulated with precision. It is desirable to complete all the work intended by the osteotome before removing it from the wound.

"When the operator thinks that the bone has been sufficiently divided, the osteotome is laid aside and a sponge saturated in 1-40 carbolised watery solution is placed over the wound. While the surgeon holds the sponge, he at the same time employs that hand as a fulcrum; with the other he grasps the limb lower down, using it as a lever, and jerks if the bone be hard, or bends slowly if the bone be soft, in an inward direction, when the bone will snap or bend as the case may be."

Neither sutures nor drainage-tubes are required.

For the after-treatment, *see* previous chapters.

Comment.—The highest part of the articular surface of the femur is a good guide to the level of the lowest part of the incision.

Great care must be taken that the line of the bone-incision is appreciated and accurately followed.

In normal limbs—as Dr. Macewen points out—a line

drawn transversely across the bone from the adductor tubercle will pass into the middle of the external condyle, whereas in the femur in a case of severe genu valgum such a line would pass into the upper part of that condyle (B, Fig. 155). If the osteotome be not carefully directed, it is apt to land in the wide tract of bony tissue forming the outer condyle.

Again Dr. Macewen writes: "For a short distance above the condyles the femur has a much thicker outer than inner border; in many instances the outer is twice as thick as the inner.

"If the form of the bone be not borne in mind, the surgeon may think that he has divided it sufficiently, and yet he may find that it will not yield, owing, in most cases, to the posterior outer part remaining intact."

In young subjects up to fifteen or sixteen, the division of the internal two-thirds of the bone will usually suffice, the remainder being broken; but in adults, especially when the bone is hard and brittle, the section should be more complete, and as little fracturing should be attempted as is possible.

In children one osteotome will suffice for the division of the bone.

If care be not exercised, it is possible for the femur to be split longitudinally.

The incision employed is above the level of the articular ligaments.

The cut in the soft parts may be made transversely, and be so placed as to correspond to the intended bone incision. By this means the osteotome is more readily introduced and more easily re-inserted should it be accidentally removed during the operation. The transverse incision spares the soft parts from a certain amount of bruising and disturbance, but it does not favour so complete a subcutaneous method.

Although the synovial pouch of the knee-joint reaches as high as the level of the bone incision, it is not in the way of the actual wound itself, since it tapers to the middle line as it ascends. A certain amount of fat intervenes between the synovial pouch and the bone, and the osteotomy cut is posterior to the pouch.

There is but little bleeding. The femoral artery cannot be in danger. If the knee be well flexed, the popliteal vessels are

placed as far as possible away from the operation area. The wound is above the superior internal articular artery, and below and anterior to the anastomotica magna. Bleeding from this vessel has, however, been reported as occurring during the operation.

In making the surface-wound, branches of the internal cutaneous nerve can scarcely be avoided, and some tributaries to the internal saphenous vein may be cut. The incision is anterior to the inner series of tendons about the knee, and the least amount of injury is inflicted upon the soft parts, so far as actual cutting is concerned, when the incision is longitudinal, as described in the account of the operation.

The comparative value of Macewen's operation will be considered in commenting upon the next procedure.

3. **Ogston's Operation by dividing the Internal Condyle.**

Operation.—The patient is supine. The hip and knee are flexed (the latter fully flexed), and the sole of the foot rests upon the table. The knee-joint is supported upon a sand pillow. The surgeon stands in every case on the left side of the patient, and steadies the limb with his left hand. One or more assistants hold the extremity and fix it in position.

A point is selected on the anterior and inner aspect of the femur, about an inch above the upper limit of the articular surface of the femur. A long tenotome is here introduced flatly, and is pushed downwards, forwards and outwards, until the point is felt in the inter-condyloid space. The cutting edge of the tenotome is now turned towards the femur, and as the instrument is withdrawn the tissues in the line of the deep incision are divided down to the bone.

An Adams' saw is now thrust along the track made by the tenotome, and should point directly towards the crucial ligaments. If the patella can be displaced sufficiently outwards, the point of the saw may be felt in the inter-condyloid groove.

The internal condyle is now sawn through from above downwards, and from before backwards, and when nearly severed the saw is withdrawn, the wound covered by a carbolised sponge, and the separation of the condyle completed by drawing the extended leg forcibly inwards. The loose condyle

can then be felt to be displaced upwards over the sawn surface of the femur (Fig. 158).

Neither drainage-tube nor sutures are required.

The operation has been performed by the chisel instead of by the saw.

No vessels of any magnitude ought to be wounded, but there may be considerable oozing from the cut surface of the bone. Very great care must be taken that the saw does not travel into the popliteal space.

Fig. 158.—OGSTON'S OPERATION FOR GENU VALGUM.

Comment.—This operation has been practically abandoned in favour of one of the two other methods described. Indeed, Professor Ogston himself has expressed a preference for Macewen's operation in the place of the procedure known by his name.

The objections to Ogston's operation, when compared with the two other methods, are these: The joint is opened up, the synovial membrane is torn, and both blood and bone-dust can find their way into the articular cavity. Synovitis and stiffness of the joint may therefore result. The posterior crucial ligament is damaged by the saw, the epiphyseal line is cut through, and a very large section of cancellous bone is produced.

In the other operations the joint is not opened, the wound is free from bone-dust, no ligaments are interfered with, the epiphysis is not encroached upon, and the bone section involves a comparatively small area.

With regard to the first two operations described—viz. osteotomy of the shaft and Macewen's operation—the points which have been urged in favour of the former procedure have been detailed in the comment made upon that measure. The special advantages which are claimed for the supra-condyloid osteotomy are these:—The bone is divided nearer to the seat of the deformity, and the sections of bone left by the osteotome are sufficiently wide to allow of their being brought well together and kept in safe contact during the progress of the after-treatment.

CHAPTER IV.

Osteotomy for Faulty Anchylosis of the Knee-Joint.

This operation is carried out in cases of angular anchylosis of the knee in which the deformity is considerable, in which a less complete measure would be ineffectual, and in which no active disease is present.

Operation.—The femur is divided at the same level and in the same manner as in Macewen's operation. The osteotome, however, is made to divide the anterior part of the bone in its entire breadth, and is so manipulated that the posterior laminæ of the femur are alone left unsevered. When this has been effected, the bone is straightened from behind forwards, the remaining part of the osseous tissue giving way under the gradual pressure applied.

Great care must be taken that the osteotome is not driven through the bone into the popliteal space.

The limb is adjusted as for fractured femur, and is most conveniently placed upon a Macintyre's splint.

It will seldom be safe or possible for the fully-extended position to be assumed at once. The limb is therefore put up in the posture of slight flexion.

Comment.—If the deformity be such that the femur and tibia form nearly a right angle with one another, then it is improbable that mere linear osteotomy of the femur will suffice to correct the deviation.

In such a case it may be necessary to remove a wedge from the anterior surface of the femur, or to carry out a double linear osteotomy—as Macewen advises—viz., the division of the femur as above described, and a division of the tibia just below its tuberosities (page 515).

In these cases of extreme deformity great care must be taken in extending the limb after the operation. The tissues

of the popliteal region will be much contracted, and a gradual straightening of the limb, extending over a week or more, and associated possibly with the division of certain tendons and bands of fascia, will be advisable. In general terms, it may be said that the limb may be extended with safety so long as the tibial arteries pulsate freely at the ankle.

CHAPTER V.

Osteotomy of the Tibia.

Under this title three operations will be described:—

1. Linear osteotomy just below the tuberosities.
2. Linear osteotomy for bent tibia.
3. Cuneiform osteotomy for bent tibia.

1. Osteotomy of the Tibia just below the Tuberosities.

This operation is carried out in the treatment of exceptional cases of faulty anchylosis of the knee-joint, as mentioned in the previous chapter.

Operation.—The leg is firmly fixed upon the sand-pillow with the anterior surface well exposed. In every case the surgeon stands to the outer side of the limb to be dealt with.

A spot is selected just below the tubercle of the tibia, and a transverse incision of the necessary width is made over the anterior tibial border. The osteotome is introduced and the bone divided transversely.

The instrument attacks first the anterior aspect of the bone, and then follows the internal surface until the posterior aspect is reached. The inner segment of the bone having been thus divided from before backwards, the instrument is now so directed as to cut from within outwards. In this way all the bone may be divided with the exception of its posterior lamellæ, which are fractured by pressure applied in the antero-posterior plane.

Great care must be taken of the tissues which skirt the external surface of the tibia.

The great vessels at the back of the limb are well protected by the popliteus muscle and the fascia which covers it, although in cases of long-standing anchylosis the muscle will be much atrophied.

The fibula does not require to be divided.

2. Linear Osteotomy for Bent Tibia.

This operation will suffice for the larger proportion of cases of bent tibia. Mr. Jacobson considers it to be especially applicable to cases in which the bone is bent laterally, and in which the bend is most marked at the junction of the middle and lower thirds.

The section of the bone is most usually transverse (Fig. 159).

Mr. Barker advises an oblique division of the bone. The plane of the oblique line of section must vary with the direction of the tibial curve. If convex inwards, the bone is divided from above downwards, and from before backwards; if curved forwards, the plane of section should be from above downwards, and from within outwards. It is maintained that these lines of section permit the deformity to be corrected with the least possible displacement of the fractured surfaces.

Operation.—1. If the osteotome be employed, the procedure is carried out in the manner already described, the situation of the incision depending upon the position of the bone section. The site of the nutrient canal of the tibia with its large blood-vessel must be borne in mind. In all but very exceptional instances, the bone section will be found to be below the site of the canal. The nutrient artery runs downwards in the bone.

2. If the saw be employed, the operation may be carried out as described by Mr. Jacobson:—

"The parts being cleansed, and the limb resting on its outer side on a firm sand-bag, the surgeon notes, at the anterior and inner margins of the tibia, the spot where the curve is sharpest. Fixing his left index over the inner margin, he enters a long tenotome or narrow bistoury exactly over the crest of the tibia, sends it down under the skin, over the inner surface of the bone, till its point is felt just beneath the finger; it is here pushed through the skin to make a counter-puncture for drainage. The knife, hitherto held horizontally, is now turned vertically, and cuts firmly on the bone, dividing the periosteum—thick in these cases—in one line right across the inner surface of the tibia. As the knife is withdrawn, it is made to enlarge the wound of entrance

slightly, to make room for the saw. This (Adams') is now introduced in the same way as the knife, carried horizontally down to, but not through, the puncture through the skin on the inner border of the tibia. The left index keeping guard at this spot, the saw is turned towards the bone, and cuts through the inner two-thirds of it. The entrance of the saw into cancellous tissue can be known by the diminution of

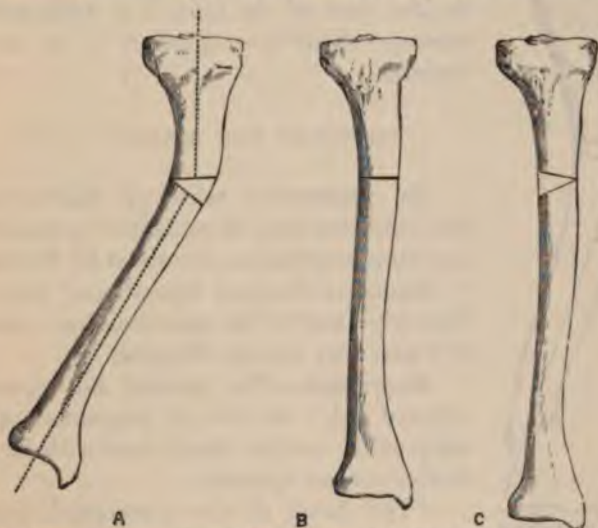

Fig. 159.—Diagram representing a curved tibia—A, With a wedge removed for the purpose of straightening the bone; B, The same with the bone straightened; C, The same with the bone simply divided and straightened. (*Modified from Little.*)

resistance and the increased bleeding which often occurs; but the best test of the depth to which the operator has arrived is the depth of the groove in which the saw has sunk.

"When the bone is sawn sufficiently, carbolised lint is placed on the wound, and the surgeon, firmly placing his two hands close together, immediately above and below the wound, sharply carries the lower fragment outwards.

"If the saw has been sufficiently used, the tibia snaps distinctly, and the fibula yields with a 'green-stick' sensation. Great care must be taken to exert the force just on the sawn portion, or the ligaments of the ankle or superior tibio-fibular joint may be strained and damaged. . . . A horsehair drain should be inserted."

Comment.—Of these two methods, the former should be selected whenever possible, for the reasons which have been already given (page 558).

Fig. 160.—Cuneiform Osteotomy for Curved Tibia.

3. **Cuneiform Osteotomy for Bent Tibia.** This operation is carried out in the manner already described (page 558). The base of the wedge will usually correspond to the crest of the tibia (Fig. 160), and will measure about three-quarters of an inch in breadth.

OSTEOTOMY FOR HALLUX VALGUS.

In aggravated cases of hallux valgus the condition may be remedied by the following simple operation, described by Mr. Barker ("Manual of Surgical Operations," page 99). The originator of the operation was a student of University College Hospital.

Operation.—The patient lies upon the affected side; the foot is supported upon a sand-pillow, and is firmly held with its inner border turned upwards.

"The head of the metatarsal bone of the great toe is defined by feeling with the fingers, and an incision about an inch long is made on its inner side, commencing over the margin of the cartilage, and dividing everything down to the periosteum, to the full extent of the incision. Through the latter the chisel is inserted, and then turned, so that its edge shall be across the neck of the bone, at a point about half an inch from the head. A few strokes of the mallet will now divide the bone almost through, the remainder being left for forcible fracture. The chisel is then withdrawn, while a sponge is pressed round its blade, and with the sponge still pressed tightly on the wound, the toe is forcibly brought inwards into a straight line. A slight antiseptic dressing, covered by a straight splint for the inside of the foot, to which the toe is secured, completes the procedure. If there be any difficulty in bringing the toe into a straight line, a

small wedge may be removed from the bone, instead of its simple section, after which the difficulty will disappear."

Comment.—No structures of importance are divided, and no sutures are necessary.

Excision of the metatarso-phalangeal joint has been performed for the relief of hallux valgus, but the operation is needlessly severe, and is in every way inferior to the measure just described.

CHAPTER VI.

Cuneiform Osteotomy for Inveterate Club-Foot.

In this operation a wedge-shaped piece of bone is removed from the outer side of the foot at the site of the medio-tarsal joint.

The cases selected for this method of treatment are examples of very extreme and intractable club-foot, which have resisted treatment by tenotomy, manipulation and apparatus, which are associated with distinct changes in the shapes of the tarsal bones, and in which it is evident that no step short of the removal of osseous tissue can alter the shape of the foot.

The rudiment of the present operation dates from 1854, in which year Dr. Little suggested the excision of the cuboid in severe talipes equino-varus, and Mr. Solly performed the actual operation involving the removal of that bone (*Med.-Chir. Trans.*, 1857, page 118). Mr. Davies-Colley removed a wedge-shaped piece of the tarsus in 1878, but with Mr. Davy must rest the credit of having formulated the present operation, and of having illustrated it by a number of cases (*Med.-Chir. Trans.*, 1885, page 139).

The Size of the Wedge.—The dimensions of the portion of bone removed must, of necessity, depend upon the degree of the deformity. In talipes equino-varus the base of the wedge is at the outer side of the foot, and is mainly represented by the cuboid; the apex will be at the scaphoid bone, the distal side of the wedge will be represented by a line at right angles to the metatarsal bones, and the proximal side by a line at right angles to the long axis of the os calcis.

In some instances the wedge is composed of portions of the astragalus, os calcis, scaphoid, and cuboid—the last-named bone predominating. In rarer cases it is found to contain portions of every one of the tarsal bones, and the bases of the four outer metatarsal bones also. The wedge has by some

surgeons, notably by Mr. Lund, been made to include the astragalus only.

In talipes equinus the base of the wedge is on the dorsum of the foot and its apex in the sole. The bones represented in the wedge are portions of the os calcis, astragalus, scaphoid, and cuboid; and, in severe cases, portions of the bones anterior to the two last-named may find their way into the wedge.

In removing a wedge of ordinary dimensions no important muscular attachments are concerned. Slips from the tibialis posticus will have to be severed, and the origin of the flexor brevis hallucis detached from the cuboid. The latter muscle will probably be represented by atrophied tissue.

OPERATION FOR TALIPES EQUINO-VARUS.

The patient is placed upon the back, with the hip and knee a little flexed, and the sole of the foot resting upon a sand-pillow on the table. The surgeon stands to the outer side of the limb, and an assistant opposite to him grasps the foot and leg, and steadies the extremity or moves it as required. The operation is usually carried out as follows:—

The outer surface of the foot having been well exposed, and the cuboid defined, an oval piece of skin is excised from the outer side of the foot over that bone. The long axis of the oval will be in the long axis of the foot, and will be equal in extent to the base of the wedge of bone to be removed. This piece of skin will include the mass of thickened epidermis and the bursa which are usually found over the cuboid.

The inner side of the foot is now exposed, and at the "stereotyped crease of skin," and in a line over the astragalo-scaphoid joint, a vertical cut is made (from dorsum to sole) of sufficient length to include the thickness of the scaphoid bone. At this incision will fall the apex of the wedge; its base is represented by the part from which the skin has been already removed.

The foot is now firmly fixed so as to bring the dorsum well into view, and with an elevator the tendons and all the soft parts are raised from the dorsum of the tarsus. The elevator is introduced through the outer incision, and the surgeon works from without inwards. The instrument must be kept close to the bone, and the area to be represented by the wedge must be laid entirely bare.

A curved director or a slender metal spatula is now introduced between the bones and the soft parts which have been raised from the dorsum. This instrument is used for the purpose of protecting the soft parts while the saw is being passed. Its extremity should present at the inner wound. A fine key-hole saw is now applied to the bones, and a wedge-shaped piece sawn out. The saw is made to cut from the dorsum towards the plantar surface, and the point of the saw should be allowed to project through the internal wound. The distal side of the wedge should be sawn first, and then the ankle-joint side. The director or protecting spatula is, of course, placed over the saw in either locality.

Great care must be exercised as the saw approaches the tissues of the sole. The wedge is now seized with lion forceps, and is loosened. As the surgeon drags upon it with the left hand, he clears the plantar surface of the bones to be removed with a narrow scalpel or with curved scissors. The wedge can usually be lifted out in one piece. Any hæmorrhage having been dealt with, the portions of the foot are brought together; and if the deformity be not fully corrected, a little more bone may be removed with the saw or with a chisel from one or other side of the wedge-shaped gap.

The large gap should now be well washed out by a stream of water from a suitable irrigator. In this way all bone-dust and *débris* are removed.

The wounds are closed with sutures, and a drain may be introduced into the lower part of the external wound.

It is not necessary that the bones be sutured together. The limb is finally placed upon a suitable splint, either upon the special apparatus designed by Mr. Davy or upon a back splint with two side splints—the outer one having an interruption—such as would be employed in the treatment of a compound fracture of the foot. A large sponge dusted with iodoform forms a suitable dressing. There will probably be much oozing at first. Primary healing may be anticipated.

The limb is treated as if it were the seat of a compound fracture of the foot.

Comment.—Mr. Davy employs an elastic tourniquet in performing this operation, but most surgeons will prefer to do without this appliance. It is quite unnecessary.

Mr. Barker would substitute for the removal of the oval piece of skin a straight incision running along the outer surface of the cuboid (from the neck of the os calcis to the base of the fifth metatarsal) in cases where there is little or no thickening of the skin over the cuboid.

Mr. Davy employs special instruments, viz., a blunt curved knife, a kite-shaped director, and a probe-pointed saw; but there is not the least difficulty in the way of performing the operation by the usual surgical instruments.

Mr. Jacobson makes a T-shaped incision with the horizontal limb along the outer side of the foot over the os calcis and cuboid, and the vertical one at a right angle to it, passing across the dorsum and ending over the scaphoid. The soft parts are raised as flaps.

In performing this operation I have in all cases employed a single horizontal incision, and have made no use of an inner wound. I have cleared the bones with a Farabeuf's rugine, and have made the section of the bones with a chisel. In most of the cases the distal bone incision has been through the cuboid, and the proximal incision through the neck of the os calcis. The apex of the wedge is at the scaphoid.

In my opinion the chisel is infinitely to be preferred to the saw. In each case up to the present time healing by first intention has followed.

Results.—Union should be firm in six or eight weeks. Mr. Davy has performed twenty-six operations, with one death. The average stay in the hospital was seventy-seven days.

All the patients have been enabled to walk and perform the daily routine of work, and have become absolutely plantigrade. A useful but slightly shortened foot results. Movement in the ankle-joint may be lost.

In some cases the application of a fixed dressing has been found necessary for some time after the splint has been removed. In others a high boot has been worn.

OPERATION FOR TALIPES EQUINUS.

The operation carried out by Mr. Davy in this form of club-foot differs but very slightly from that just described, and the general observations and comments made upon that procedure may be considered to apply to this.

The medio-tarsal joint having been defined, two wedge-shaped pieces of skin are removed—one from the outer, and the other from the inner side of the foot. The apex of each cutaneous wedge is on the plantar surface, while the base is on the dorsum, and the size of the bared area will depend upon the size of the bony wedge to be removed.

The soft parts are cleared from the dorsum, and the wedge is cut out with the saw or chisel with the same precautions and in the same manner as have been already described.

The wedge may be extracted in one piece in the form of a bony key-stone.

The after-treatment of the case is the same as has been already detailed, and the results of the few operations of this kind which have been performed are included in the remarks that precede this section.

Comment.—In the place of the cutaneous wedges, straight or T-shaped incisions may be employed. The bones are best cleared with the rugine, and the chisel is decidedly to be preferred to the saw.

OPERATION FOR CONFIRMED FLAT-FOOT.

The treatment of extreme flat-foot by the excision of a wedge of bone was introduced by Mr. Golding Bird in 1878. (*See* paper in *Lancet*, April 6th, 1889.) The wedge was taken from the inner side of the foot, and was composed either of the scaphoid alone, or of the scaphoid together with the head of the astragalus. Dr. Ogston (*Trans. Med. Soc.*, 1884) excised the astragalo-scaphoid joint in such a way that the parts removed were wedge-shaped. He then fixed the astragalus and scaphoid together with pegs.

An article by Mr. Davy (*Lancet*, April 6th, 1889) may be consulted.

The actual *operation* needs no detailed description. The bone is exposed by a simple incision, and the parts to be removed are bared with a rugine. The wedge is cut out with a chisel and mallet. No tourniquet is required. The foot is adjusted upon a suitable splint after the operation, and is treated as a compound fracture. There is no need to fix the bones together by pegs or sutures.

CHAPTER VII.

Operative Treatment of Ununited Fracture.

Without entering into the general question of the indications for interference in cases of ununited fracture, it is necessary to point out that *delayed* union of broken bones is not uncommon; that so-called non-union depends upon many conditions, some constitutional, some local; and that often in cases which have apparently become hopeless much can be done by general treatment and by simple local measures which are short of operation.

1. ununited fracture of long bones.

In dealing with ununited fractures of such bones as the femur, the humerus, the tibia, and the radius, the operative measure which appears to me to be the best, the simplest, and the most complete consists in resecting the ends of the broken bone, and then retaining them in accurate apposition by means of splints. Of the different measures of which I have myself made use, none has given such satisfactory results as has this simple procedure.

Certain of the modes of treatment advised have little to recommend them. Among such must be named the passing of a large tenotome between the fragments, the introduction of a seton, the insertion of gilt steel needles into the bone, or the driving-in of a number of ivory pegs.

These timid and half-hearted measures were possibly justified in the days which preceded the introduction of antiseptic methods in the treatment of wounds. They are feeble measures, which are blindly administered, and which appear to trust more to good-fortune than to sound science.

At the present day—when the making of a large wound is (within reasonable limits) not much more serious than the making of a small one—these imperfect operations have little reason for their existence.

The introduction of a seton is a distinctly dangerous and reckless measure; the passage of a tenotome may not be dangerous, but it is purposeless, and has every prospect of being futile.

If the bone has to be exposed in order that it may be drilled and stimulated by ivory pegs, it is a question—when once the deep wound has been made—whether the best possible procedure is being carried out.

If a considerable mass of muscular tissue intervenes between the fragments, the pegs will do little good, and the risks of the wound will have been incurred for nothing.

After the resection operation, on the other hand, the ends of the broken bone, freshened and freed of all intervening tissue, are brought into actual and close contact, and may be said to be placed in the best condition for uniting. If the surgeon be of opinion that the formation of new bone will be stimulated by the introduction of ivory pegs, this measure may be adopted as an additional feature of the operation.

The question of wiring the fragments will be considered in a separate section.

The Operation by Resecting the Ends of the Bone.

Before undertaking this operation, the surgeon should understand that its success depends more upon the completeness of the arrangements that are made for keeping the bones in position after the operation than upon the operation itself, provided the latter be carried out with due care. The operation involves the making of a compound fracture, the limb is at the time flail-like and distorted, the muscles are shortened, the fragments are very possibly displaced.

In these circumstances it is necessary that the most efficient form of splint should have been prepared, and that all arrangements should have been made for fixing the limb and maintaining such extension as may be necessary.

In dealing with a fracture of the femur in an adult, it is well that the operation be performed as the patient lies upon the bed he will occupy throughout the whole treatment. Much moving of the patient after the operation is very undesirable, and a long thigh splint with extension apparatus cannot be conveniently applied upon the operation-table.

Care in the adjusting of the fragments, and infinite and continued care in the after-treatment, are the main elements of success in the present class of case.

The principal features of the *operation* are the following:—

1. The strictest antiseptic measures must be observed. It is essential that the wound should heal without suppuration.

2. The incision must be free. In many instances the wound must be very extensive. A small incision may greatly complicate the operation, may prevent the full exposure of the bones, and may lead to undue contusion and laceration of the soft parts. The surgeon is likely to err in the direction of making the wound too small rather than too large.

3. The wound should be in the long axis of the limb as a rule, and should be so placed as to reach the bone by the shortest route and with the least damage to the soft parts—the nerves and the blood-vessels of the region.

4. The bones must be well exposed and cleared of the fibrous and cicatricial tissue which will probably surround them. This tissue need not be removed, but the bones must be well freed of it.

5. The free end of each fragment should be made to project in turn through the wound. To effect this the limb will probably require to be bent at an acute angle at the seat of fracture, large and strong retractors will be required, and the help of able assistants.

6. Each bone-end should be bared of its periosteum, which is turned back by means of the rugine with as little disturbance of its connections with the surrounding soft parts as is possible. It is only necessary that the actual free end of the bone be so laid bare.

7. With a fine and sharp chisel the operator should then proceed to remove a thin lamella from the end of the bone, so that the fresh cancellous tissue is exposed over the entire section of the shaft. No more need be removed than is necessary to expose a surface of living vascular and active bone. Both fragments are to be treated in the same way. The manner in which the bone is cut is of great importance. The chisel should be so employed that the two raw surfaces can lie in contact, and can, if possible, overlap.

While there is applied to the limb the fullest amount of extension that an assistant can exercise, the surgeon should ascertain what position the fragments will occupy when the limb is finally adjusted upon the splints he has prepared; and he should, if necessary, re-apply the chisel until the two fragments fit one another, and are made to lie easily in contact when the deformity has been corrected.

Mere sawing-off of the ends of the bones is not sufficient, nor is the mere baring of the broken extremities all that is required. The bones must be fashioned, and be so moulded with the chisel that they may be brought into proper contact.

During the use of the chisel every care must be taken by means of spatulæ and retractors, held by watchful assistants, to protect the soft parts. I have found it convenient to steady the limb against an iron block covered with a carbolised towel during the time the chisel is being used.

8. The wound cavity should then be well flushed out with a 1-50 carbolic solution, directed into its depths by a suitable irrigator. Sutures are applied, but the close approximation of the margins of the skin wound is not desirable. I have never employed a drainage-tube in these cases. The use of the elastic tourniquet is to be avoided whenever possible.

The best dressing for the wound is a large sponge, or a pad of Tillmann's dressing, well dusted with iodoform.

The limb must finally be well and carefully secured upon a splint, and fixed in the best possible position. It may be necessary to divide a tendon now and then, or sever rigid bands of cicatricial tissue.

In neglected fractures of the thigh, in which non-union has followed, I have kept the patient in bed for a week or so before the operation, and have applied extension during the whole of that time, in order to overcome the shortening produced by contracted muscles and to bring the limb into a good position.

This preliminary measure allows the swelling which often surrounds the seat of fracture to subside, and enables the surgeon to make trial of the splint he proposes to employ after the operation.

The after-treatment of these cases differs in no way from that of compound fracture.

The Operation by Wiring the Fragments.

So far as the long bones of the extremities are concerned, I think that this measure may very well be dispensed with.

I made use of it at one time, but have had good reasons for abandoning it.

In the first place, the wire can play but a feeble part in maintaining the fragments in position.

It is not consistent with simple mechanical principles to assume that a single loop of soft wire can have great effect in keeping together the broken ends of so huge a bone as the femur, especially when the thigh is that of a well-developed adult. The boring of the bones and the passing of the wire are often very difficult and tedious steps in the operation, and may greatly extend the length of the operation. Much damage has been done to the soft parts in this stage of the proceeding.

When the wire is being twisted, the bones may appear to be in good position; but when the splint is applied, or the attitude of the limb altered, the wire may be found to have but little hold upon the fragments.

The wire may be so applied as to actually prevent the best possible adjustment of the fragments.

It is true that the loop may be retained indefinitely without the patient being conscious of its presence in the limb; on the other hand, it has caused much irritation, has induced intense neuralgic pain, has apparently led to suppuration and to a limited necrosis of the end of the bone.

In the case of a superficial bone, such as the tibia, the wire loop may cause ulceration of the skin, and I had on one occasion to remove such a wire on this account many months after its introduction.

It is said that the wire excites the growth of new bone; but if it does, it appears to effect its end at a great cost.

The removal of the wire after a period of six or eight weeks is often a matter of the greatest difficulty, especially when the wound has soundly healed. A large incision may be required, much bruising of the soft parts may be involved, and at the end the loop often breaks, and a piece of the wire has to be abandoned in the depths of the limb.

If the ends of the wire be allowed to project through the

wound, an unnecessary complication of the operation is involved, and the wire acts the part of a seton.

On the other hand, if care be taken to correct the shortening so far as possible before the operation, if every measure be observed which will improve the local condition of the limb, and if the bone-ends be brought well together during the operation, an apparatus will keep the fragments in position, provided the surgeon is careful in the selection of the appliance, and still more careful in the details of the after-treatment.

It is probable that in the case of both the humerus and the femur a considerable degree of extension may have to be maintained, but the use of the wire would not make that necessity the less.

I have operated by the resection method above described upon ununited fractures of the humerus, femur, tibia, and radius, and have obtained better results by that means than ever attended the earlier operations in which I wired the fragments together.

As a practical measure the wire is a delusion and a snare; so far, certainly, as the long bones are concerned.

2. UNUNITED FRACTURE OF SHORT BONES.

The bones considered under this heading are the patella and the olecranon.

The Patella.—It is assumed that such operations as are here described are applicable to cases of ununited fracture, cases in which treatment has been ineffective, and in which considerable impairment of the use of the limb has resulted. It must be assumed also that the question of wearing an instrument has been considered as an alternative to operative interference, and that the gravity of any measure which involves the opening of the knee-joint has been discussed.

It would appear that the treatment of recent simple fractures of the patella, by opening the knee-joint and wiring the fragments together, has not come into general use among surgeons. Indeed, it must be confessed that in the great majority of cases a very satisfactory degree of success attends the ordinary and simpler modes of dealing with the fracture.

In cases of compound and comminuted fractures the

question of wiring fragments together in the primary treatment of the lesion may be considered in certain instances.

1. *The Wiring of the Fragments.*—This operation was introduced by Sir Joseph Lister in 1883, and is carried out, it is needless to say, under the most careful antiseptic precautions.

The knee being extended, a vertical incision is made along the front of the knee-joint over the centre of the patellar fragments. This median cut may commence one inch above the upper fragment, and end one inch below the lower.

The integuments having been separated by retractors, the fragments are exposed, and their fractured surfaces are cleared of the fibrous tissue and the thickened synovial membrane which will cover them.

These surfaces, when freed, are then freshened by removing a thin slice of the bone with a fine, narrow chisel.

In effecting this each fragment should be steadied by means of lion forceps, the blades of which are without teeth. A small piece of sponge should be pressed beneath the fragment to prevent blood from running down into the knee-joint.

The lower fragment, which is usually also the smaller, is the less easy to deal with of the two.

The bones are now drilled in the median line with a carpenter's bradawl. The drill-hole runs obliquely from the upper or lower attached surface of the bone (as the case might be) to the deeper layers of the bone which are next to the cartilage, and which are exposed on the newly-freshened surface (Fig. 161).

It is important that the drill-holes should be both precisely in the median plane, or the fragments will be tilted when the bone is tightened.

Pure silver wire one-sixteenth of an inch thick is now introduced, and, after the sponges have been removed and the joint washed out, the fragments are brought together and the ends of the wire secured by means of one complete turn. If the wire has to be removed, the direction of the twist should be noted.

Those who advise that the wire be retained, cut the ends short, and, twisting the stump of wire laterally, hammer it flat upon the bone (Fig. 161).

If necessary, the knee-joint may be drained by means of a

small tube or a strand of horse-hair passed through the posterior part of the capsule of the joint. Such a drain will probably be removed at the end of twenty-four hours.

The limb is adjusted upon a straight back-splint, the skin-wound is closed with sutures at the last moment, and the after-treatment of the case is simply that of fracture of the patella.

The fragments cut square and the wire in position.

Fragments in apposition. The wire knot hammered flat.

Fig. 161.—WIRING OF THE FRAGMENTS OF THE PATELLA AFTER FRACTURE. (*Barker.*)

Comment.—The transverse incision advised by some writers has little to recommend it, especially when there is much separation of the fragments.

The freshening of the bony surfaces with a saw is a proceeding that is to be condemned.

There is often considerable difficulty in bringing the fragments into close contact, and some partial division of the rectus muscle may be necessary before this end can be attained.

When the lower fragment is of very small size, the difficulties of the operation are increased.

2. *The Use of Malgaigne's Hooks.*—I have already mentioned certain objections which appear to me to apply to the wiring of the fragments in dealing with ununited fractures of the long bones.

In the operation just described the wire has been left *in situ* in a great many instances, has given rise to no trouble, and has led to most excellent results. In a few cases, however, trouble has supervened. The foreign body has set up irritation, has caused pain, has prevented kneeling, has induced ulceration of the skin, and finally has led to caries of the bone and suppuration of the knee-joint. (*See* cases cited by Jacobson, "Operations of Surgery," page 1030, *et seq.*)

The removal of the wire at the end of six or eight weeks is attended with difficulty, involves the opening up of the wound, and the attempt has often resulted in the removal of a portion of the wire only.

The following method, which I have carried out with very satisfactory results in several instances, appears to avoid certain of the objections which may be urged against wiring:—

The first part of the operation is conducted precisely in the manner already described; the fragments are exposed and their surfaces are freshened, but, instead of drilling the bones and bringing them together with wire, they are approximated and held in position by a pair of modified Malgaigne's hooks. (*See* paper by the author, *Brit. Med. Journ.*, July 24, 1886.)

The points of the hooks are inserted on each side of the median line, are driven through the uninjured skin, and are forced well into the bone near its attached margin (upper or lower border, according to the fragment dealt with). As the instrument is in two separate parts, the hooks are at first fixed into the fragments independently, and the whole apparatus is made one when the two hook-carrying plates are brought together.

The plates are now screwed together, and if the bones cannot be brought close to one another they may be approximated as nearly as is possible, and the screw tightened daily until they are in close contact. In exceptional cases it may be necessary to divide some fibres of the rectus muscle.

In most instances no drain is required. The limb is secured to a straight back-splint, and placed upon an inclined plane. The wound is entirely closed by sutures, and it and the apertures formed by the hooks are buried in iodoform.

The general management of the hooks is discussed in the paper already alluded to.

The hooks should be retained for some six weeks.

Although I have employed this instrument in a large number of cases, and in patients of various conditions, I have never had suppuration follow, and in no instances has there been any substantial rise of temperature. The removal of the hooks can be effected with the greatest ease.

I would venture to draw attention to the following points which appear to me to be in favour of this method:—

CHAPTER VIII.

Excision of Joints and Bones.

GENERAL CONSIDERATIONS.

By the term "excision of a joint" is implied the removal of the articular extremities of the bones entering into the formation of the joint, together, necessarily, with the cartilage and synovial membrane, the procedure being carried out with the least possible amount of injury to the surrounding soft parts.

This definition, while it applies precisely to the usual excisions of the knee and elbow, is allowed also to include the usual excisions of the hip and shoulder in which only the articular extremity of the long bone forming the joint is removed.

By excising a joint it is often possible to preserve a limb which, but for this operation, would be subjected to amputation

The excision of a bone may apply either to the complete removal of a bone together with its articular extremity, *e.g.*, the inferior maxilla; or to the removal of a portion of a bone, *e.g.*, the diaphysis of the humerus, or the acromial end of the clavicle.

History of Excision Operations.—In the works of the older writers, from Hippocrates downwards, the removal of bone is advised in certain general terms and in certain conditions. Under the influence of this advice it would appear that among ancient surgical operations must be placed the removal of sequestra and the sawing-off of the irreducible ends of bones that have been exposed in compound fracture or compound dislocation.

The excision of a joint as a definite surgical measure is, however, quite a modern operation, and dates from the latter end of the last century.

With the invention and introduction of the operation two names are conspicuously associated—Park, of Liverpool; and

Moreau, of Bar-sur-Ornain. The early work of these two surgeons appears to have been independent of one another.

Park performed excision of the knee on July 2, 1781, for chronic joint-disease. The patient was a sailor aged thirty-three, and he made a perfect recovery (Park's letter to Mr. Percival Pott, September 18, 1782).

Moreau carried out an excision of the ankle on August 13, 1782 ("Essai sur l'Emploi de la Résection des Os," by Moreau the younger, Paris, 1803), and performed excision of the shoulder in 1786, and excision of the elbow in 1794.

Prior to the operations of Park and Moreau certain procedures of a less definite and deliberate character had been carried out. Thus, Felkin of Norwich had excised the knee for disease in 1762 (the operation being recorded in one of Park's letters). Bent, of Newcastle, performed excision of the shoulder in October, 1771 (*Philos. Trans.*, 1774), and Orred repeated the procedure in 1778 (*Philos. Trans.*, 1779).

The first excision in modern times for compound dislocation is ascribed to Cooper, of Bungay. The joint concerned was the ankle, and the operation was performed some years prior to 1767. (*See* "Gooch's Cases and Practical Remarks on Surgery," 1767.)

The first excision of the hip was performed in 1818 by Anthony White, of the Westminster Hospital (*London Med. Gazette*, 1832, page 352). Vigarous, of Montpellier, advised excision of joints in the treatment of certain gunshot injuries ("Opuscules," 1788), and Percy appears to have carried the operation out in 1799.

Charles White, of Manchester, removed in 1708 a considerable portion of the diaphysis of the humerus ("Cases in Surgery, with Remarks," London, 1770), with the result that the deficiency was so made good by new bone that the case attracted great attention.

In the *Philosophical Transactions* for 1766 is "an account of the extraction of three inches and ten lines of the bone of the upper arm, which was followed by a regeneration of the bony matter, with a description of a machine made use of to keep the upper and lower pieces of the bone at their proper distances," by Prof. Le Cat, of Rouen; translated by Justamond.

These early operations were not very extensively imitated, and, indeed, the procedures of Park and Moreau were so vigorously condemned by many that for some years excisions were but very rarely performed.

The development of the operation was the work of later surgeons. In Great Britain the credit of placing excision of the shoulder and of the elbow among recognised methods of treatment must rest with Syme; and a like comment may be applied to Ferguson, so far especially as the knee and the hip-joints were concerned. Hancock brought excision of the ankle into the scope of modern surgery, and Lister the operation for excising the wrist.

The credit of the subperiosteal method must rest with Ollier, of Lyons. Few men have done more for the operative surgery of the joints and bones than has this surgeon. His elaborate and most admirable treatise on resections contains the most complete account of excisions with which literature has been at present provided. His researches into the growth and formation of bone and the action of the periosteum are well known, and his classical work should be consulted by all who desire a fuller knowledge of the operations with which this chapter deals.

The part played by the periosteum in the formation of bone was first discussed by Duhamel in 1739-43. The matter was further developed by Heine (1837), and Flourens (1840), and still later by Wagner (1853). Textor, Syme, Blandin, and Chassaignac all made a point of preserving the periosteum in their resections. Their examples, however, do not appear to have been extensively followed, and the precise subperiosteal method is due to Ollier, whose first monograph upon the subject appeared in 1858.

Some further details relating to the history of these operations are given in the account of each particular procedure.

The Instruments employed.—The following is the list of the instruments that may be required in an excision operation:—

Scalpels. Bistouries (blunt and sharp pointed).
Dissecting and artery forceps. Pressure forceps.
Scissors. Bone forceps. Sequestrum forceps.

Probes; directors; special directors.
Excision knives.
Ivory or metal spatulæ. Retractors of various kinds.
Lion forceps.
Periosteal elevators. Rugines.
Saws of various kinds.
Chisels and Mallet.
Bone gouges. Sharp spoons.

Certain of these instruments require a special notice.

The Excision Knife.—This knife should have a large handle and a short but stout blade (Fig. 162). It is an instrument by means of which the surgeon can give the short, strong, clean and heavy cuts down to the bone which are so conspicuous a feature in excision operations. Fig. 162 shows the most useful form of knife for general purposes. Fig. 163 represents an excision knife with a straight edge, which will be found very convenient in dealing with some irregular surfaces, and also in dividing the periosteum.

The Periosteal Elevator or *Rugine.*—Many patterns of

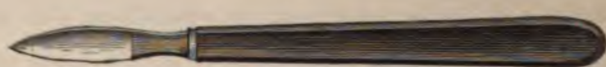

Fig. 162.—EXCISION KNIFE.

Fig. 163.—EXCISION KNIFE.

this instrument exist. The rugine, or *détache-tendon*, is employed to strip the periosteum from the bone.

The most convenient instruments are those of Farabeuf. Fig. 164 shows the straight rugine, which will meet with the requirements of most operations; and also the curved rugine, which is admirably adapted for curved and irregular surfaces. It has likewise been used as a conductor or director for the chain-saw.

The ordinary periosteal elevator (Fig. 165), as it is figured in the catalogues of English makers, is a useful instrument.

It is of little service in actually detaching the periósteum, but is useful in raising it when it has been detached.

Retractors.—Retractors play a very important part in excision operations. Those of the ordinary pattern will suffice. (*See* page 40.) The most serviceable are of steel and are rectangular.

Fig. 164. — FARABEUF'S RUGINES, STRAIGHT AND CURVED.

A useful retractor can be made with a long, thin, and narrow strip of pliable metal (*e.g.*, malleable iron plated). Its application in a case of excision of the elbow is shown in Fig. 187.

Good ivory spatulæ are of great service to protect the soft parts during sawing.

Saw Directors.—Blandin's director of the pattern shown in Fig. 166 is of value in protecting the soft parts when the

Fig. 165.—LANGENBECK'S PERIOSTEAL ELEVATOR.

saw is being applied. It is, indeed, made to act as a director for the saw.

It can be employed also as a guide in passing the chain-saw around a bone.

Fig. 166.—BLANDIN'S DIRECTOR FOR RESECTIONS.

Lion Forceps.—Of the various forms of lion forceps or bone-holding forceps, Farabeuf's is perhaps the best.

By means of its double axis it is enabled to grasp firmly a bone of any size, and will hold a metacarpal bone as steadily

as it will fix the head of the humerus (Fig. 167). The *davier-érigne* shown in Fig. 168 is admirably adapted for grasping soft and friable bones.

Fig. 167.—FARABEUF'S BONE-HOLDING FORCEPS.

Saws.—The particular kind of saw employed must depend upon the taste and custom of the individual surgeon. The best for most excision operations is a simple straight narrow saw with a movable back. In some instances, *e.g.*, in certain excisions for anchylosis, a rat-tail or key-hole saw is needed.

If it be considered needful to give a curved surface to the

Fig. 168.—OLLIER'S FORCEPS FOR SEIZING CANCELLOUS OR FRIABLE BONE.

free end of the bone, this may best be done by means of a slender Butcher's saw.

French surgeons are for the most part in favour of the chain-saw, but that instrument has never held a very prominent position with English operators.

The General Conditions of Excision Operations.

The remarks in this and the following chapters apply especially to excisions of joints, but they may be taken as referring also, with appropriate modification, to resections of bones.

The excision of a joint may be practised for the relief of any of the following conditions:—Advanced joint-disease; disease of the articular ends of the bones; injury, such as gunshot wound, compound or unreduced dislocation; anchylosis; and certain deformities.

The great majority of the cases of excision have been carried out for the relief of strumous or tubercular disease of the joint (" white swelling "); and the chief discussions relative to excision, and the main statistics that deal with the operation, are concerned with excisions for chronic joint-disease.

In performing excision of a joint, the following general points are to be observed :—

1. The whole of the diseased tissue must be removed.

2. The amount of the bone removed must be limited by such common surgical requirements as are necessary to ensure the prospect of a useful—or, at least, not utterly useless—limb. It is possible to remove so much bone that although the wound heals firmly and well, the patient is left with a flail-like limb, which is an actual encumbrance. " Figurez-vous," writes Farabeuf, " un genou et même un coude de caoutchouc, la jambe ou l'avant-bras oscillant au gré de la pesanteur ! " The common observation that " any limb is better than no limb " is not to be accepted entirely.

3. The soft parts must be as little disturbed as possible. The surgeon's object should be to remove nothing but bared bone, free of all its periosteum. Every care must be taken to preserve the connections of tendons and ligaments, and to avoid injury to vessels and nerves of any magnitude.

4. Care must be taken in young subjects that the active epiphysis be not destroyed, lest a greatly-shortened limb result—a matter of infinite consequence in the lower extremity.

5. The bones must be so divided as to be adapted to the purposes of the new articulation, or be favourable for anchylosis in a good position. In excising the knee-joint, it is possible that one careless operator may bring about a condition of knock-knee in the healed limb, and another a condition of bowed leg.

6. The after-treatment must be a matter of infinite patience and infinite care; and the selection of a suitable apparatus for the fixing of the limb is a subject of considerable moment. In the upper extremity, and in the hip and ankle, a joint capable of some degree of movement is expected after the excision ; in the knee anchylosis is generally sought for.

7. The surgeon must be fully alive to the general surgical aspects of the case, to the condition of the patient, to his prospects of standing a long and severe operation, and to his capacity for exhibiting vigorous powers of repair. An excision is to some extent a plastic operation, and good and substantial healing is a necessity.

It thus happens that in the practice of most, an excision is

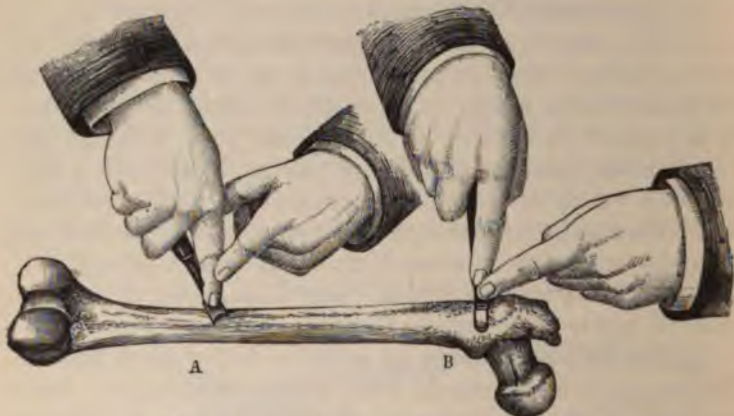

Fig. 169.—THE METHOD OF USING THE RUGINE.
A, Over a level, and B, over an unequal surface. (*Ollier.*)

never done in the very young, nor in subjects over forty, and this more especially applies to excisions for disease.

In carrying out an operation, it is well to avoid an Esmarch's tourniquet. Many excisions involve a considerable expenditure of time; and to render the limb bloodless during the whole of that period is most undesirable. The general objections to the "bloodless method" have been already detailed. These objections conspicuously apply to the present class of operations.

The oozing that follows the use of the elastic band is especially marked after these operations, and tends to interfere with the dressing of the case, to retard healing, and to place difficulties in the way of a rigid adjustment of the limb.

The skin incisions must be considered with great care.

The more modern operations favour the most simple form of wound—a single straight cut.

The measures adopted by some of the earlier operators were very complex and needlessly extensive.

The Open Method and **the Subperiosteal Method.**

The excision of a joint may be carried out by either of the two methods just named.

The Open Method.—In the open method (the *méthode du bistouri* of the French) the bones are exposed through the simplest and most direct incision; the soft parts are disturbed as little as is possible; any tendons which may be attached to the bones to be excised are not cut through, but are peeled off or separated from their point of attachment. The ligaments of the joint, or certain of them, can hardly escape division.

The bones are protected, and are sawn off, but no care is taken to separate and preserve the periosteum which is attached to them.

The Subperiosteal Method.—In the subperiosteal method (the *méthode de la rugine*) the articular ends of the bones are exposed, probably through a similar incision to that observed in the open method. The great object of the operator, however, is to save the whole of the periosteum of the involved district, and at the same time to preserve the capsular ligament intact. The process may be illustrated by such a joint as the elbow. The articular ligaments (namely, the anterior, posterior, internal lateral, and external lateral) form together a complete capsule, which joins above and below with the periosteum of the bones of the forearm and upper arm.

The osseous tissue to be removed is shelled out from within this investment of periosteum and ligament. The capsule, and the periosteum into which it extends above and below, are divided in one vertical incision. The gap made is enlarged; the bones are decorticated; they are stripped of periosteum, but at the same time the connections between that membrane and the capsule of the joint are not disturbed. The articular ends when bared are then protruded through the incision or incisions made in this capsulo-periosteal sheath (*la gaine périosteo-capsulaire*). The term *résection sous capsulo-périostée,* applied by French surgeons to this method, serves to

emphasise the fact that the procedure consists of something more than the mere preservation of periosteum (Fig. 170).

The ligaments of the joints retain their original connection, and any attached tendons—such as that of the triceps—are separated with the capsulo-periosteal sheath, its

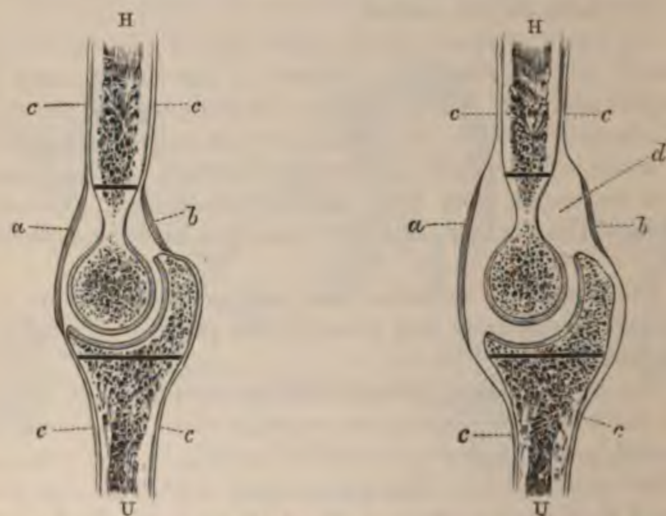

Fig. 170.—DIAGRAMS TO ILLUSTRATE THE SUB-PERIOSTEAL METHOD OF RESECTION.

H, Humerus; U, Ulna; *a*, Anterior ligament; *b*, Posterior ligament; *c*, Periosteum; *d*, Capsulo-periosteal sheath separated by the rugine. (The lines of the saw-cuts are shown.)

relations to the investing membrane of the bone not being disturbed.

The advantages and disadvantages of the sub-periosteal method.—The advantages claimed for the sub-periosteal method are the following:—

(*a*) The periosteum being preserved, new bone is formed to replace that which has been removed.

(*b*) The capsule of the joint is preserved, and the connections of the ligaments are not severed; the new articulation is therefore likely to be all the stronger.

(*c*) The connections of the tendons with the periosteum are not disturbed, and greater muscular strength is consequently given to the new joint.

(*d*) There is much less hæmorrhage, the chief area of the operation being subperiosteal.

(*e*) Planes of connective tissue are not opened up, and the cavity left after the removal of the bones is limited and circumscribed by the capsulo-periosteal sheath.

With regard to these claims, there is no doubt but that, in favourable circumstances, a large quantity of new bone is produced to make good that lost by the operation.

The importance of the periosteum in this connection would appear to be paramount, although some recent writers have adduced evidence in support of the view that the bone-forming functions of the periosteum have been over-estimated.

In the most successful cases it cannot be said that the articular ends of the bone are reproduced, and that the new joint is a reproduction of the old. New bone is formed, and fills the periosteal cavity, and by the periosteum it is limited and moulded (Fig. 171). The new bone is, as it were, poured into a mould. The amount produced varies. In some instances no new bone is produced even when a considerable portion of the periosteum is saved; in other cases an excessive amount is found to have been formed; in a few examples the reproduction of the details of the lost bones has been precise and remarkable. In all circumstances it would appear that the new bone is a little unstable, and that it is liable to undergo a certain but varying amount of re-absorption.

The value of the new bone so produced cannot be over-estimated when the results of operations come to be compared, and the main advantage of the subperiosteal method may be considered to be based upon this feature.

The preservation of ligaments and tendinous connections is another advantage of this method—an advantage that is substantial and definite.

The disadvantages of the subperiosteal operation cannot, on the other hand, be overlooked.

The measure is admirable in theory, but it does not always assume so immaculate a position in practice.

In the first place, the detachment of the periosteum is difficult and tedious. The student who attempts a subperiosteal resection for the first time upon the cadaver will find, especially if the subject be old, that the periosteum is not

so substantial a membrane as it is sometimes represented, and that its separation is a matter of considerable mechanical difficulty. When the complex surface of the lower end of the humerus, for example, is dealt with, it is not improbable that the rugine will detach the membrane in shreds. In traumatic cases, in adults, the surgeon will find in practice that the strict carrying out of the method of Ollier is barely possible.

The operator who blindly persists in following this method will often find that, after much valuable time has been exhausted, he has bared the bone of periosteum, but has left that membrane in shreds and holes.

It is not only the operator's surgical faith which suffers from the tyranny of a method; the patient also is troubled, and in a more material way.

In young subjects the periosteum is thicker, more active, more substantial, and more easily stripped off. It may also be said that it is more precious, and is in more need of being preserved.

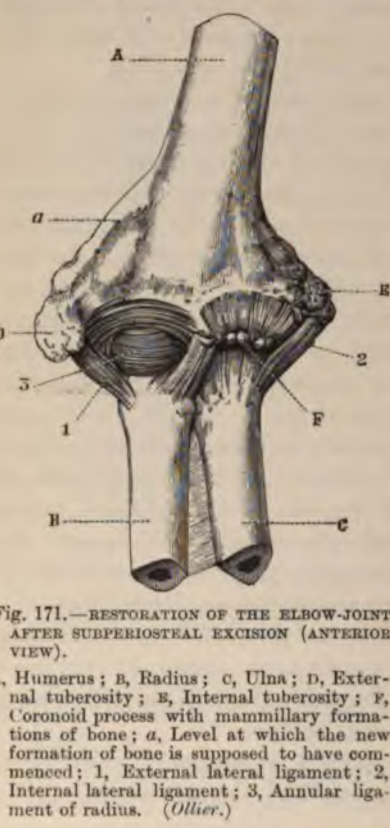

Fig. 171.—RESTORATION OF THE ELBOW-JOINT AFTER SUBPERIOSTEAL EXCISION (ANTERIOR VIEW).

A, Humerus; B, Radius; C, Ulna; D, External tuberosity; E, Internal tuberosity; F, Coronoid process with mammillary formations of bone; *a*, Level at which the new formation of bone is supposed to have commenced; 1, External lateral ligament; 2, Internal lateral ligament; 3, Annular ligament of radius. (*Ollier.*)

In cases attended by chronic inflammation the periosteum is generally very easily detached, but in such a condition it is often of doubtful value. It may be infiltrated with inflammatory material, may hinder the healing of the wound, and may even maintain suppuration. But if it lack these potentialities for evil, it may possess no bone-producing property.

In cases of excision performed for new growth the preserva-

tion of the periosteum will, in nearly every instance, be most undesirable.

In the next place, the subperiosteal operation involves a considerable period of time in the performance, and the shock following the procedure may be not inconsiderable. In this respect it compares unfavourably with an excision by the open method, where the actual steps of the operation are simple and the process quick.

Summary.—It may be said, in conclusion, that the subperiosteal operation is excellent in theory, but it is only excellent in practice in selected cases. Although it is the procedure which should be adopted whenever possible, it can never become a routine method of performing excision. It is, indeed, of somewhat limited application. A partial subperiosteal resection may often be carried out in instances where the complete operation is impossible, and there must be few cases in which it is not desirable to take every precaution to preserve the connections of ligaments and the periosteal attachments of tendons.

The open method, practised as it was in the earlier days of surgery, when ligaments and tendons were divided without scruple, may be safely regarded as a matter of the past; but such a modification of this method as the subperiosteal procedure suggests is of great and wide-extending value.

Circumstances that Influence the Result of Excision Operations.

So far as excisions of joints are concerned, the conditions that may be considered under this heading are very numerous, and can only be dealt with in outline. They concern not only those general circumstances that influence the healing of wounds and the recovery of patients after operation, but embrace certain local features that are more or less obvious.

The success of the operation will depend upon the age of the patient, upon his condition, upon his powers of exhibiting repair from extensive wounds, and upon the general circumstances that affect primary healing.

His nervous condition is a matter of importance, as is also his capacity for submitting to a tedious and often painful after-treatment. The question of antisepticism needs but to be

mentioned. So far as the operation is concerned, much will depend upon the state of the tissues, upon the nature of the disease, upon the amount of bone removed, upon the complete elimination of the morbid structures, and upon the safety of important tissues in the vicinity of the operation.

The After-treatment.

Few operations can be cited in which the after-treatment is more important, and in which it has a greater influence upon the success of the case. However well the excision may have been carried out, and however favourable the case may be, the whole complexion may be altered and transformed by neglect in the after-treatment.

The wound must be kept aseptic, and in general terms it may be said that dry and infrequent dressings should be mainly relied upon.

The splint must be selected with care, and must be applied with precision. The principal features in the after-treatment are identical with those attending the care of compound fractures.

The position of the limb must be accurately prescribed. If anchylosis be wished for, the bones must be brought into close contact, and must be kept in very rigid relation with one another.

If it be intended that a movable articulation should result, then the approximation of the bones should be less close.

No rule can be given that will render definite the precise degree of separation of parts that is desirable after the operation. The approximation will be less close in adults than in young subjects, and in cases where much periosteum has been preserved than in those where much has been lost.

It may be that a week or so will have to elapse before the surgeon can satisfy himself that the adjustment of the sawn ends of the bones is the best that can be attained.

In some instances, notably those associated with existing deformity of the joint, it may not be wise to enforce the ideal position at once, but the limb will have to be brought gradually into the desired attitude.

When mobility is desired, passive movements will have to be undertaken. These may generally be commenced as soon as the inflammatory symptoms have subsided, and as soon as

the sensitiveness of the part has become less acute. In most cases this will be represented by a period varying from one to three weeks.

The treatment of the general health, the duration of the treatment by apparatus, and the employment of massage and electricity will depend upon general principles.

Results.

Ollier's statistics deal with 274 cases of excisions of joints performed by himself between the years 1861 and 1884. The mortality of the whole series is 31·02 per cent., which Ollier divides in the following manner:—

Deaths from the actual operation	13·13 per cent.
Deaths due to a continuation of the primary disease (tuberculosis)	13·13 „
Deaths from intercurrent diseases	4·75 „

The mortality after excisions for injury was 51·8 per cent., and after excisions for disease 28·4 per cent.

The mortality due to the actual operation prior to the employment of antiseptic measures—*i.e.*, before 1878—was 23·3 per cent., and after that was 4·8 per cent.

MacCormac gives the following as the mortality following individual resections for disease. The period covered is from 1876 to 1885 inclusive, and all the operations were performed at St. Thomas's Hospital:—

Shoulder	10·0 per cent.
Elbow	2·4 „
Wrist	0·0 „
Hip	7·8 „
Knee	9·0 „
Ankle	7·1 „

Otis gives the mortality after resections of various kinds for gunshot injury as 27·6 per cent.

The mortality after excisions in general is high before five years of age and after thirty. The most favourable results are obtained in children.

In England these operations are not very frequently performed. At the London Hospital, during the four years ending December 31, 1888, only thirty excisions of articulations were performed (twelve of the elbow, ten of the knee, four of the wrist, and four of the hip). Of this number one patient died, after excision of the hip, from tubercular meningitis.

CHAPTER IX.

Excisions of the Fingers, Thumb, and Metacarpus.

These operations are but seldom required, and can but very rarely be carried out upon precise and systematic lines.

Most of the so-called excisions of bones consist of removing large necrosed fragments, such as that formed by the ungual phalanx after whitlow, or as may be produced in the diaphysis of a metacarpal bone.

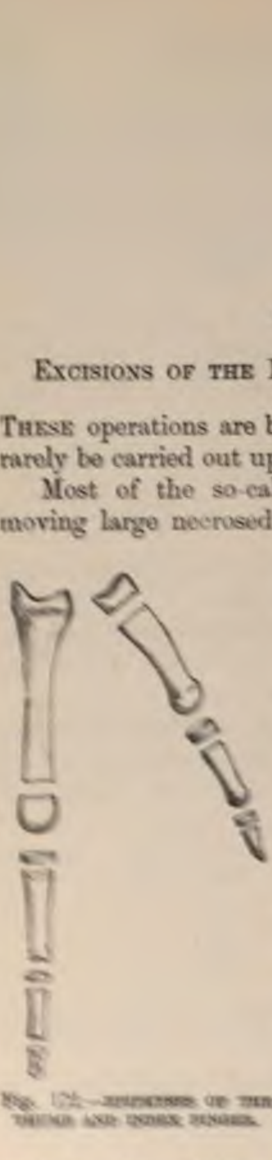

Fig. 172.—Epiphyses of the thumb and index finger.

Not a few of the bone excisions in this region described in some text-books could scarcely ever be applied to the living subject.

Excisions of the joints have been carried out in the treatment of suppurative inflammation, anchylosis, deformity, and unreduced dislocation, and have, with certain reservations, proved moderately successful.

Anatomical points.—The phalanges and metacarpal bones consist of a shaft and of one epiphysis.

In the four inner metacarpal bones the epiphysis is at the distal end of the bone, and forms the head. In the metacarpal bone of the thumb and in the phalanges the epiphysis is at the proximal extremity (Fig. 172).

There is usually a trace of an epiphysis in the head of the first metacarpal bone about the age of seven years.

The epiphyses commence to ossify about the fourth year, and join the shafts about the twentieth year.

1. Terminal Phalanges.

The ungual phalanx may be conveniently excised through a U-shaped palmar incision, which will circumscribe the pulp of the digit. The curved extremity of the U is brought close to the nail. The base of the little bone should be preserved if possible, as it forms the epiphysis and gives attachment to the flexor profundus digitorum.

2. Inter-phalangeal Joints.

A single lateral incision is made upon one or other side of the joint in the long axis of the phalanx. If the cut be placed opposite to the centre of the digit—as regards its width from dorsum to palm—the vessels and tendons will be avoided (Fig. 173, B).

The lateral ligament being divided, the bones are made to protrude, are carefully cleared of soft parts, and are then removed with a very fine saw. To safely effect this section a grooved curved director should be introduced to receive the saw.

If two lateral incisions be employed, the operation is rendered much easier.

3. Metacarpo-phalangeal Joints.

Precisely the same method is employed as in the above case. If a single lateral incision be made use of, it should be placed externally in the case of the thumb and index finger, internally in the case of the little finger, and to one or other side of the dorsal aspect of the joint when the other metacarpo-phalangeal joints are concerned (Fig. 173, A and C).

4. Metacarpal Bone of the Thumb.

In this little operation the subperiosteal method should, whenever practicable, be very precisely carried out.

The hand is held firmly upon a table, with the radial side uppermost.

An incision is made along the outer side of the metacarpal bone, and is so placed as to lie over the lateral border of the bone and to be upon the anterior or palmar side of the extensor tendons. The incision is carried in one direction over the metacarpo-phalangeal joint, and in the other over the trapezium (Fig. 173, D).

In dividing the soft parts, care is taken to avoid the branch from the radial nerve to the outer side of the thumb.

The bone is exposed, and the separation of the periosteum

is commenced at the centre of the shaft. Small rugines are required, the surgeon using at first a straight one and afterwards a curved instrument. The soft parts are cleared up to the head of the bone, where the structures of the joint are separated and the head of the bone is made free.

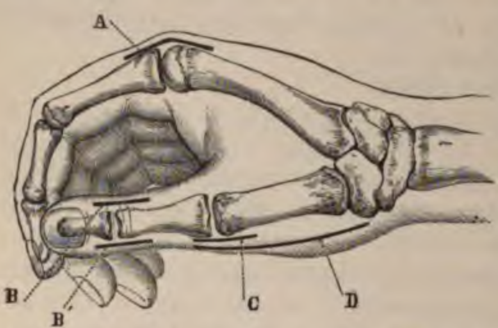

Fig. 173.—A, Excision of metacarpo-phalangeal joint of index; B B, Excision of inter-phalangeal joint of thumb; C, Excision of metacarpo-phalangeal joint of thumb; D, Excision of first metacarpal bone.

This end—quite stripped—is made to protrude through the wound, and is seized and held by lion forceps.

The surgeon then proceeds to decorticate the rest of the bone as far back as the proximal joint. The muscular attachments are separated with the periosteum, and the whole bone is removed.

It will be obvious that this subperiosteal method can only be carried out under quite exceptional circumstances, and in young subjects.

Whether the subperiosteal method be pursued or not, the steps of the operation will be the same.

5. Metacarpal Bones of the Fingers.

An incision is so made along the dorsal aspect of the metacarpal bone as to avoid the extensor tendons. The bone is exposed, and the centre of the shaft is well cleared. Around this portion of the bone—when entirely freed—a much-curved director is passed, and the bone is divided by means of cutting forceps. Each divided end can now in turn be seized with lion forceps, be freed of its soft parts, and be removed. The bone is therefore excised in two segments.

Comments and Results.—It is certainly better, whenever possible, to excise the ungual phalanx rather than to amputate the end of the digit.

Excisions of the inter-phalangeal joints have afforded very satisfactory results.

Excision of the metacarpo-phalangeal joint of a finger is not an operation in favour of which much can be said. It is apt to leave a flail-like finger, which is possibly an actual source of inconvenience.

In young subjects this operation should not be performed, as it involves the destruction of the epiphysis of both the metacarpal bone and of the phalanx.

Excision of the metacarpo-phalangeal joint of the thumb has, on the other hand, been followed by very excellent results. The importance of saving any part of a thumb is well recognised, and a most useful digit has been left after the removal of portions of the metacarpal bone of the thumb. This especially applies to cases in which the base of the bone —which represents the epiphysis—has been left.

The results which have followed the resection of the entire bone have not been very satisfactory, even when the subperiosteal method has been carefully carried out. This method should be adopted in all cases of excision of the first metacarpal bone, unless distinctly contra-indicated or impossible.

Small portions of the shafts of the metacarpal bones of the fingers have been removed without much impairment of the hand; but excision of the entire bone, even when performed subperiosteally, is a useless operation. The finger concerned is deformed, and more or less powerless and in the way. The same may be said of such excisions as involve the removal of the whole of the epiphysis.

CHAPTER X.

Excision of the Wrist.

This operation, when complete, consists in the removal of the whole of the carpus, the lower ends of the radius and ulna, and the articular extremities of the metacarpus.

It has been performed in cases of chronic bone disease involving the carpus, and in chronic joint disease implicating the articulations of the wrist and hand. It has been carried out also in certain cases of injury, and in the treatment of gunshot wounds, unreduced dislocations, and anchylosis.

Excision of the wrist appears to have been first performed by Moreau in 1794. The patient, a man aged 71, died. The operation was not favourably regarded by surgeons, and for many years Moreau had few imitators. In 1865 Sir Joseph Lister published an account of an operation (*Lancet*, vol. i., 1865, page 308) in which he for the first time insisted upon the importance and showed the possibility of removing the whole of the diseased bones. He made use of a dorso-radial incision, and his operation was no doubt the forerunner of the methods now in vogue.

Boeckel had in 1862 employed a single dorso-radial incision, but it was not until 1867 (*Gazette méd. de Strasbourg*, 1867, page 184) that he perfected his procedure and applied the subperiosteal method to excision of the wrist. Langenbeck (*Archiv. für klin. Chirurgie*, 1874) followed Boeckel practically without modification. Ollier's operation—which is described below as the best method—is but a modification of the original procedure of Boeckel.

Anatomical Points.—The wrist-joint is separated from the lower radio-ulnar joint by the triangular cartilage which is attached by its apex to the styloid process of the ulna and by its base to the inner margin of the articular surface of the radius, where it blends with the articular cartilage.

The joint is protected by strong tendons. On the inner side are the extensor and flexor carpi ulnaris; on the outer side the extensor ossis metacarpi pollicis, the extensores primi and secundi internodii pollicis, and the two radial extensors of the carpus; in front are the deep and superficial flexors of the fingers, the flexor longus pollicis, palmaris longus, and flexor carpi radialis. Posteriorly are the tendons of the extensor indicis, extensor communis, and extensor minimi digiti.

These tendons, on passing the wrist, are—with the exceptions of the palmaris longus and flexor carpi ulnaris—enveloped by the synovial sheaths, the positions of which are shown in Fig. 174.

Fig. 174.—SECTION THROUGH THE WRIST. (*After Henle.*)

A, Scaphoid; B, Os magnum; C, Semilunar; D, Semilunar; E, Unciform; F, Cuneiform; G, Pisiform; H, Compartment for flexor tendons; I, Flexor carpi radialis; J, Extensor ossis, metacarpi pollicis, and extensor primi; K, Extensores carpi radialis longior and brevior; L, Extensor secundi internodii pollicis; M, Extensores communis and indicis; N, Extensor minimi digiti; O, Extensor carpi ulnaris; P, Palmaris longus; *a*, Ulnar vessels; *b*, Radial vessels; 1, Ulnar nerve.

The bones are united by means of a capsular ligament of which the anterior part (the so-called anterior ligament) is the strongest portion. The posterior part is quite thin. More substantial fibres exist upon the lateral parts of the capsule—the so-called external and internal lateral ligaments.

A more or less complete layer of ligamentous tissue covers the anterior and posterior surfaces of the carpus, and to thickened portions of it various names are given. Ollier would have the carpus regarded surgically as one short wide bone, capped with cartilage at either end, and covered with ligamentous tissue of unequal thickness.

In the wrist and the carpus are seven separate synovial sacs, the disposition of six of which is shown in Fig. 175. The seventh sac is a minute one between the pisiform and cuneiform bones.

It will be observed that the sac between the trapezium and the first metacarpal bone is quite distinct.

Figs. 176 and 177 show the position and extent of the lower epiphyses of the radius and ulna. They join with the shafts of their respective bones about the twentieth year. The lower extremity of the diaphysis of the ulna just reaches to the radio-ulnar joint; the lower end of the diaphysis of the radius is intra-synovial.

Fig. 175.—THE SYNOVIAL CAVITIES OF THE WRIST.

The carpus is entirely cartilaginous at birth, and the bones commence to ossify between the first year (os magnum) and the twelfth year (pisiform) after birth. The trapezium is an important bone from an operative point of view. It supports the thumb, is in very close relation with the radial artery, forms a groove for the flexor carpi radialis, and gives attachment to the opponens pollicis, the abductor pollicis, and the flexor brevis pollicis.

The tendons at the back of the wrist can be well made out in the healthy hand. The most conspicuous belongs to the extensor secundi internodii pollicis. It is rendered distinct when the thumb is extended and abducted. It leads up to a small but prominent bony elevation on the back of the radius, which marks the outer border of the osseous groove for its reception. This tendon, when it reaches the radius, points to the centre of the posterior surface of that bone, and indicates also roughly the position of the interval between the scaphoid and semilunar bones.

The lower end of the ulna is very distinct. When the hand is supine, its styloid process is exposed at the inner

and posterior aspect of the wrist to the inner side of the extensor carpi ulnaris. In pronation, however, the process is rendered less distinct, while the head projects prominently on the posterior part of the wrist, and is found to lie between the tendons of the extensor carpi ulnaris and extensor minimi digiti.

The tip of the styloid process of the ulna corresponds to the line of the wrist-joint, and a knife introduced below that joint would enter the articulation.

A knife entered horizontally just below the tip of the styloid process of the radius would hit the scaphoid bone.

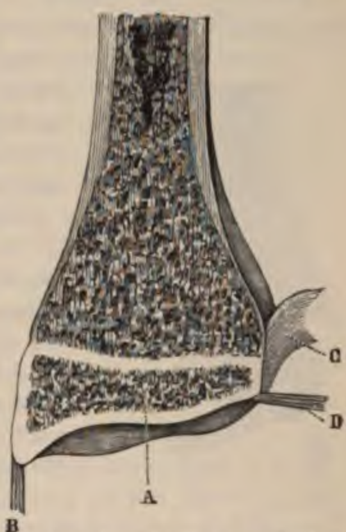

Fig. 176.—LOWER END OF THE RADIUS IN A SUBJECT AGED 16. (*After Ollier.*)
A, Epiphysis; B, Lateral ligament; C, Synovial membrane of radio-ulnar joint; D, Triangular ligament.

A line drawn between the two styloid processes slopes downwards and outwards; its two extremities represent the extreme inferior limits of the radio-carpal joint, and it fairly corresponds to the chord of the arc formed by the line of that joint. The line between the styloid processes is nearly half an inch below the summit of the arch of the wrist-joint.

The radial artery winds round to the back of the wrist, just below the styloid process of the radius, lying upon the external lateral ligament of the joint, and between the extensors of the metacarpal bone and first phalanx of the thumb. It then runs over the scaphoid and trapezium, and, as it is about to dip between the two heads of the abductor indicis, is close to the carpo-metacarpal joint of the thumb.

The position of such branches of the radial and ulnar arteries as are distributed in the neighbourhood of the wrist must be borne in mind. The vessels most apt to be wounded in excision of the wrist are the radial, the deep palmar arch,

the anterior and posterior carpal arches, and the dorsal interosseous branch of the radial.

1. **Ollier's Operation (by two Dorsal Incisions).**

Those surgeons who have most conspicuously concerned themselves with excision of the wrist urge that the operation should, whenever possible, be performed by the subperiosteal method, and that that method should be observed even in instances when it must on account of local conditions be of necessity incomplete.

Fig. 177.—LOWER END OF THE ULNA IN A SUBJECT AGED 16. (*After Ollier.*)

A, Epiphysis; B, Synovial membrane; C, Triangular ligament; D, Lateral ligament.

Ollier's operation appears to me to be the best of the many methods which are at present employed for excising the wrist. The procedure is merely a modification of Boeckel's operation, and, so far as the external incisions are concerned, does not differ very conspicuously from the still older method of Lister.

Operation.—The patient lies upon the back, and the hand is placed on a small table by the side of the operation table, and is allowed to rest upon a large sand-bag covered with macintosh. The surgeon sits facing the patient. Such adhesions as prevent a moderate degree of movement should be broken down. It is better that an Esmarch's tourniquet should not be used. The operation is of considerable duration, and the oozing which follows the removal of the elastic band is usually very considerable, and is a great obstacle to healing.

(*a*) The Incisions.—Two landmarks are taken, viz., the centre of a line uniting the two styloid processes and the tendon of the extensor indicis, or, in default of it, the base of the second metacarpal bone. The radial incision commences opposite to the centre of the shaft of the second metacarpal bone, and is continued obliquely upwards along the outer side of the extensor indicis tendon to a point corresponding to the centre of a line uniting the two styloid processes. From this

point the incision is carried vertically upwards in the line of the long axis of the limb (Fig. 178, A).

In a large hand the whole incision will measure about 4½ inches—3 inches of the length being below the line of the articulation, and 1½ inch above it.

Having divided the integuments, the surgeon brings the extensor indicis into view, but without opening its sheath.

It is drawn gently outwards by means of a hook, and the insertion of the extensor carpi radialis brevior is sought for. The knife is now carried well down to the bones along the whole length of the incision. This cut will commence to the inner side of the tendon last named, and will fall upon the base of the third metacarpal.

The capsule of the joint is opened, the posterior annular ligament is divided, and the upper part of the deep incision falls in the interval between the extensor indicis and the extensor secundi internodii pollicis.

The former tendon is, with the extensor communis, drawn inwards, the latter outwards.

The ulnar incision is now made. It extends from a point one inch and a quarter above the tip of the ulnar styloid process to a point one inch and a quarter above the base of the fifth metacarpal bone. It is placed to the inner side of the extensor carpi ulnaris.

The incision is carried down to the bones, and falls upon the ulna, the cuneiform, and the unciform.

In making these incisions care should be taken not to cut the dorsal branch of the ulnar nerve to the little finger, or the internal division of the dorsal branch of the radial nerve.

(*b*) The Removal of the Carpus.—Starting from the incisions already made, the surgeon proceeds to strip the carpal bones of their ligamentous and periosteal coverings. Small rugines of various shapes are used for this purpose. The decortication may be most conveniently commenced on the radial side, and the dorsal aspect of the bones be exposed before the palmar. As each bone is freed, it should be seized with forceps and removed. Diseased bone is removed by means of the gouge. The bones of the ulnar side will be removed through the ulnar incision.

The pisiform bone may usually be left. The unciform

process may be cut through and removed subsequently if found diseased. The trapezium should be saved whenever possible.

This is the most tedious part of the operation, especially if the subperiosteal method be strictly adhered to.

(c) The Removal of the Ends of the Radius and Ulna.—The hand is now loose. The lower ends of the bones of the forearm are bared of periosteum as high up as is necessary. They are made to protrude through the wound, and are divided by means of a fine saw. If very little disease exists, a liberal gouging of the parts may meet the needs of the case.

(d) The Removal of the Ends of the Metacarpal Bones.—This may not be necessary. As little of these bones is removed as is possible, and the section will probably extend no further than the limits of the carpal synovial sacs.

The bones are made to project through the wound, and are severed as required by means of a fine saw.

(e) The wound is united, a drainage-tube is introduced, and the hand is adjusted upon a special splint.

Comment.—This operation must be subject to very considerable modification. It is tedious and difficult, and involves infinite care. It may be impossible to carry out the subperiosteal method completely. Ollier maintains that if this method be completely observed, the attachments of no tendons are lost.

By the open method the tendons of the two radial extensors of the carpus, the tendons of both the extensor and the flexor of the ulnar side of the carpus, the flexor carpi radialis tendon, and possibly that of the supinator longus, may be sacrificed. The two first-named tendons are, indeed, cut through.

The steps of the operation may be altered. The radius and ulna may be sawn through first, and, the carpus being exposed in the wound, the bones may be removed one by one as they are reached.

By this means the palmar surfaces of the carpal bones can be more easily freed of their periosteo-ligamentous covering.

If a considerable portion of both radius and ulna has to be removed, each bone may, when freed of periosteum, be divided

by a fine chain saw. Throughout the operation small instruments and good retractors must be used.

The decortication of the bones is very difficult in certain cases and in other than young subjects. On the ordinary dissecting-room subject it is often almost impossible. When the parts have long been involved in chronic inflammation, the separation of the periosteum is easier.

In most cases the hand is already distorted, the joints are stiff, the soft parts are greatly thickened, the area of the operation is occupied by many sinuses, and the synovial sheaths of the tendons have been more or less obliterated by disease.

Fig. 178.—EXCISION OF THE WRIST.
A A′, Ollier's incision for radial side; B B′, Boeckel's incision.

2. **Other Methods.**

It is needless to speak of the method of excising the wrist through a dorsal flap, as practised by Velpeau, nor of the H-shaped incisions once in vogue.

Maisonneuve in 1853 (*Gazette des Hôpitaux*, 1853, page 280) made use of a single median dorsal incision, and of late years more than one surgeon has revived this procedure in a modern form.

(*a*) *Boeckel's Operation.*—This is sometimes described as Langenbeck's operation, the two procedures being practically identical. A single dorsal incision is made upon the radial side. This incision is straight, is placed in the interval between the extensor indicis and the extensor secundi internodii pollicis, and is made to closely follow the radial border of the first of these tendons (Fig. 178, B). In a large hand the incision is about

four and three-quarter inches in length, extending three and a quarter inches below the joint-line, and one inch and a half above it. In a small hand the cut would be about three and a half inches in length, reaching one inch and a quarter above the line of the articulation, and two and a quarter inches below it.

The tendons of the extensors of the radial side of the carpus are cut, the operation is carried out subperiosteally, and in the manner already described.

The incision is not quite so conveniently placed in this operation as it is in Ollier's, and the latter procedure is rendered simpler by the introduction of a small ulnar incision.

Boeckel's incision renders it almost impossible to avoid cutting the extensor carpi radialis brevior tendon.

The bend in the wound-line in Ollier's operation is mainly for the purpose of avoiding this tendon.

(*b*) *Sir Joseph Lister's Operation.*—This may be taken as a good example of the open method of excision, as distinguished from the subperiosteal plan.

The operation is thus described by Mr. Jacobson, his account being a little fuller than that given in the original text. The radial incision is made as in Fig. 179:—"This incision is planned so as to avoid the radial artery, and also the tendons of the extensor secundi internodii and indicis. It commences above, at the middle of the dorsal aspect of the radius, on a level with the styloid process. Thence it is at first directed towards the inner side of the metacarpo-phalangeal joint of the thumb, running parallel in this course to the extensor secundi internodii; but on reaching the line of the radial border of the second metacarpal bone, it is carried downwards longitudinally for half its length, the radial artery being thus avoided, as it lies a little farther out. These directions will be found to serve, however much the parts may be obscured by inflammatory thickening. The tendon of the extensor carpi radialis longior is next detached with the knife, guided by the thumb-nail, and raised, together with that of the extensor brevior, also cut; while the extensor secundi internodii, with the radial artery, is thrust somewhat outwards. The next step is the separation of the trapezium from the rest

of the carpus by cutting forceps applied in a line with the longitudinal part of the incision, great care being taken of the radial artery. The removal of the trapezium is left till the rest of the carpus has been taken away, when it can be dissected out without much difficulty, whereas its intimate relations with the artery and neighbouring parts would cause much trouble at an earlier stage. The soft parts on the ulnar side are next dissected up as far as possible, the hand being bent back to relax the extensors.

"The ulnar incision should be made very free, by entering the knife at least two inches above the end of the ulna immediately anterior to the bone, and carrying it down between the bone and flexor carpi ulnaris, and on in a straight line as far as the middle of the fifth metacarpal bone at its palmar aspect. The dorsal lip of the incision is then raised, and the tendon of the extensor carpi ulnaris cut at its insertion, and its tendon dissected up from its groove in the ulna, care being taken not to isolate it from the integuments, which would endanger its vitality. The finger extensors are then separated from the carpus, and the dorsal and internal lateral ligaments of the wrist-joint divided; but the connections of the tendons with the radius are purposely left undisturbed.

"Attention is now directed to the palmar side of the incision. The anterior surface of the ulna is cleared by cutting towards the bone so as to avoid the artery and nerve, the articulation of the pisiform bone opened, if that has not been already done in making the incision, and the flexor tendons separated from the carpus, the hand being depressed to relax them. While this is being done, the knife is arrested by the unciform process, which is clipped through at its base with pliers.

"Care is taken to avoid carrying the knife farther down the hand than the bases of the metacarpal bones; for this, besides inflicting unnecessary injury, would involve risk of cutting the deep palmar arch. The anterior ligament of the wrist-joint is also divided, after which the junction between the carpus and metacarpus is severed with cutting pliers, and the carpus is extracted from the ulnar incision with sequestrum forceps, and by touching with the knife any ligamentous connections.

"The hand being now forcibly everted. the articular ends of

the radius and ulna will protrude at the ulnar incision. If they appear sound, or very superficially affected, the articular surfaces only are removed. The ulna is divided obliquely with a small saw, so as to take away the cartilage-covered rounded part over which the radius sweeps, while the base of the styloid process is retained. The ulna and radius are thus left of the same length, which greatly promotes the symmetry and steadiness of the hand, the angular interval between the bones being soon filled up with fresh ossific deposit. A thin slice is then sawn off the radius parallel with the articular surface. For this it is scarcely necessary to disturb the tendons in their grooves on the back, and thus the extensor secundi internodii may never appear at all.

Fig. 179.—Excision of the wrist. (Lister's incision.)

"This may seem a refinement, but the freedom with which the thumb and fingers can be extended, even within a day or two of the operation, when this point is attended to, shows that it is important. The articular facet on the ulnar side of the bone is then clipped away with forceps applied longitudinally.

"If the bones prove to be deeply carious, the pliers or gouge must be used with the greatest freedom. The metacarpal bones are next dealt with on the same principle, each being closely investigated—the second and third being most readily reached from the radial, the fourth and fifth from the ulnar side. If they seem sound, the articular surfaces only are clipped off, the lateral facets being removed by longitudinal application of the pliers.

"The trapezium is next seized with forceps and dissected out, without cutting the tendon of the flexor carpi radialis, which is firmly bound down in the groove on the palmar aspect, the knife being also kept close to the bone to avoid the radial. The thumb being then pushed up by an assistant,

the articular end of the metacarpal bone is removed. Though this articulates by a separate joint, it may be affected, and the symmetry of the hand is promoted by reducing it to the same level as the other metacarpals.

"Lastly, the articular surface of the pisiform is clipped off, the rest being left, if sound, as it gives insertion to the flexor carpi ulnaris, and attachment to the anterior annular ligament."[1]

After-treatment.—The wound must be well drained, be dressed with the most careful antiseptic precautions, and the cavity of the wound be frequently washed out.

The limb must be maintained upon a splint which will support the palm of the hand, will keep the wrist a little extended, and the fingers a little flexed, while at the same time it will not prevent movements of the fingers from being carried out. Lister's wooden splint with a cork pad is simple, and answers well (Fig. 180).

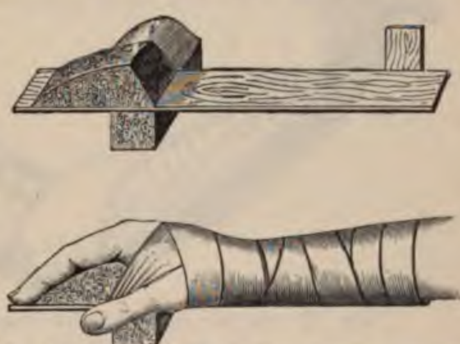

Fig. 180.—LISTER'S SPLINT FOR EXCISION OF THE WRIST.

The splint used by Ollier is shown in Fig. 181. It is made of wire, and when in actual use is lined with lint or cotton-wool. It has this advantage—that the supporting iron can be bent, and the position of the part therefore changed from time to time as the patient progresses. The wound, moreover, is more accessible.

The thumb is apt to be drawn inwards to the index finger. This is prevented in Lister's splint by the use of a suitable pad. In Ollier's splint a wire loop (a) enables the thumb to be maintained in any position wished.

There is a constant tendency for the hand to assume the position of adduction, and this is apt to become more marked some time after the splint has been removed.

The limb will need to be maintained upon a splint for a considerable period, varying from two to six months.

It is essential during the whole of this time that passive movements of the fingers be kept up. The fingers should be moved as early as the third day. The wrist should be kept at rest until the parts have become consolidated, when passive movements may be commenced. Active movements of the fingers should be undertaken as soon as the patient can move without pain.

For some time after the splint is left off, the patient should wear a leather support, and should be persistent in his attempts

Fig. 181.—OLLIER'S WIRE SPLINT FOR EXCISION OF THE WRIST.
a, Support for the thumb, if required.

to exercise the wrist and fingers, and to increase the range of their movements.

Results.—The results of this operation are, on the whole, not very satisfactory. Since the introduction of antiseptic measures the mortality is low, but is nevertheless higher than that which attends amputation of the forearm. In very carefully selected and very favourable cases some results have certainly been excellent. Ollier records several instances in which the patient recovered with a very useful hand, capable of performing a large series of movements, to support weights, and to bear pressure. In such cases fibrous anchylosis has taken place, leaving a moderate degree of movement at the wrist, and a free action of the tendons of the fingers.

In contrast to one such conspicuous result must be placed a large number of reported, and possibly a still larger number

of unreported, cases in which a malformed and useless hand has resulted—a hand thickened, rigid, and uncouth, with stiffened fingers, fixed tendons, and open sinuses—a limb the seat of continued pain, and more or less completely useless.

In the most common form of trouble involving the carpus and wrist-joint—viz., strumous disease of bone and synovial membrane—excision of the wrist can only in quite exceptional cases be justifiable. Under long-continued and careful treatment, which will involve the removal of diseased tissue from time to time, the majority of these cases do very fairly well; and if the disease will not yield to such measures, it may be doubted whether either the patient or the limb is in a favourable condition for so extensive an operation as the present procedure involves.

CHAPTER XI.

EXCISION OF THE RADIUS AND ULNA.

PORTIONS of the bones of the forearm, and indeed the whole of the diaphysis of one or both of these bones, have been removed by operation for the relief of various conditions.

These operations have been carried out in cases of extensive bone disease, in certain instances of gunshot injury, in cases of new growth (myeloid sarcoma) attacking the bones, and in some examples of deformity following injury.

The whole subject is very fully dealt with by Ollier in his *Traité des Résections* (vol. ii., 1889).

The Ulna.—The ulna, being a comparatively superficial bone, is easily reached. Its posterior border is subcutaneous from the olecranon to the styloid process.

The incision is made along this posterior border, and the bone is reached between the anconeus and the flexor carpi ulnaris in the highest part of the diaphysis and between the latter muscle and the extensor carpi ulnaris in the lower two-thirds or three-fourths of the bone. The chief mass of muscular tissue from which the bone must be freed, belongs to the flexor profundus digitorum, which is extensively attached to both the anterior and the internal surfaces.

It must be remembered that the dorsal branch of the ulnar nerve winds backwards beneath the flexor carpi ulnaris at about some two to three inches above the wrist.

Whenever possible, the resection of the bone should be carried out by means of the subperiosteal method.

The Radius.—The bone is approached from the external surface by an incision parallel to the long axis of the bone, and so placed as to open the interstice between the supinator longus and extensor carpi radialis longior muscles.

In this inter-muscular space the radial nerve is sought for.

This nerve lies throughout beneath the supinator longus, but about three inches above the wrist it turns backwards beneath the tendon of the muscle to become subcutaneous. The nerve may be followed up until the point is reached at which the musculo-spiral bifurcates into the radial and posterior interosseous nerves.

The periosteum is divided over the outer border of the bone, and the insertion of the pronator teres separated and turned forwards. The supinator brevis muscle is divided vertically; one part is turned forwards with the radial nerve, the other is turned backwards with the posterior interosseous nerve.

This method of exposing the radius originated with Mr. Henry Morris, whose very successful case of removal of a considerable part of both the radius and the ulna was published in the tenth volume of the *Clinical Society's Transactions.*

The excision should be subperiosteal whenever possible. In the case of operation for sarcoma, this method would, however, not be admissible.

In young subjects the restoration of parts after subperiosteal resection of the diaphysis of these bones—and notably of the radius—has been very complete and remarkable. On the other hand, very lamentable deformity has attended extensive resections of the radius in which the periosteum was not preserved, or in which the epiphyses were encroached upon.

CHAPTER XII.

Excision of the Elbow.

This operation consists in the removal of the lower end of the humerus and the upper extremities of the radius and ulna.

It is performed for advanced cases of bone and joint disease which have resisted milder treatment; for certain cases of injury, notably gunshot wounds; for the relief of anchylosis when in a faulty position; and for some examples of unreduced dislocation. The object aimed at is the production of a movable joint. A description of the operation upon the dead body was given in 1782 by Park ("On a New Method of treating Diseases of the Knee and Elbow," 1783), and in the same year excision of the elbow was proposed by Moreau (*Mémoire à l'Académie de Chirurgie*, 1782).

The first actual operation appears to have been performed by Moreau in 1794. Previous to 1782 large fragments of dead bone had been removed from the elbow by operation, and the lower end of the humerus had been excised in at least one case of compound dislocation (Wainman, 1759).

In England the operation was popularised by Syme, and was enthusiastically adopted by British surgeons.

Anatomical Points.—The elbow is a pure hinge-joint, permitting normally of no lateral movement. The synovial membrane of the superior radio-ulnar joint joins that of the major articulation.

The crease in the skin called the "fold of the elbow" is placed some little way above the line of the joint.

The bony points about the elbow can be well made out in a healthy subject.

The internal condyle is the more prominent and the less rounded of the two. The humero-radial articulation forms a horizontal line, but the humero-ulnar joint is oblique, the joint surfaces sloping downwards and inwards. Thus it happens that while the outer condyle is only three-quarters

of an inch above the articular line, the tip of the internal condyle is more than one inch above that part.

A line drawn through the two condyles will be at right angles with the axis of the upper arm, while it will form an angle with the axis of the forearm.

The joint-line is equivalent to only about two-thirds of the width of the entire line between the points of the two condyles.

In extreme extension the tip of the olecranon is a little above the line joining the two condyles.

Of the ligaments of the elbow-joint the anterior and posterior are comparatively thin. The internal lateral is the strongest and most extensive of the ligaments. In excision it is very important that the external lateral ligament should be, whenever possible, preserved, since it joins below with the articular ligament.

Fig. 182.—DIAGRAM OF HUMERUS AT AGE OF 15.

A, Internal condyle; B, Line of attachment of anterior part of capsule.

The three most important muscles in relation to this operation are the biceps, the brachialis anticus, and the triceps. The insertion of the two first-named muscles should never be divided. The biceps is inserted into the tubercle of the radius, the brachialis anticus into the anterior surface of the ulna at the root of the coronoid process. A section of the ulna sufficiently low to include the whole of the coronoid process will not involve a sacrifice of the insertion of the brachialis anticus. The triceps insertion occupies not only the upper flat surface of the olecranon, but also a considerable portion of each of the sides of that process.

From the triceps tendon come off two considerable lateral expansions, which descend obliquely to join the deep fascia of the forearm (Fig. 188). Of these the internal is insignificant. The external expansion is, however, considerable, and should always be saved, as it enables the triceps to retain a hold of the forearm, even after the olecranon has been removed.

The anconeus and supinator brevis muscles must be seriously disturbed in any excision of the elbow. The other muscles in very immediate relation with the joint are the extensor carpi radialis brevior and the extensor carpi ulnaris.

One great danger in this operation is division of, or damage to, the ulnar nerve as it lies in the groove between the olecranon and the internal condyle.

Fig. 183.—UPPER END OF THE RADIUS IN A SUBJECT AGED 15. (*After Ollier.*)
A, Epiphysis; B B', Synovial membrane.

Another nerve which is very readily injured in this operation is the posterior interosseous, which is placed in jeopardy when the upper end of the radius is being bared.

The composition of the arterial plexus which surrounds the elbow-joint on all sides, and supplies it, must be held in mind.

The lower epiphysis of the humerus is of large size, and contains four separate osseous nuclei. The main mass of the epiphysis joins the shaft about the sixteenth or seventeenth year, the nucleus forming the internal condyle joins at the eighteenth year. That part of the epiphysis which forms the radial condyle and the trochlea is within the capsule of the joint. That part which forms the two condyles is without the synovial cavity (Fig. 182).

The upper epiphysis of the radius forms the head of the bone, is within the synovial cavity of the joint, and joins the shaft between the sixteenth and seventeenth years (Fig. 183).

The olecranon process is mainly formed from the diaphysis; indeed, more than three-fourths of its greater sigmoid cavity belongs to that segment of the bone.

The upper part of the olecranon is at birth cartilaginous. At the tenth or eleventh year a small nucleus of bone appears on the highest part of the process, and forms a very slight epiphysis, which represents only the highest or flat surface of the olecranon, and is little more than a mere shell of bone. This little epiphysis joins the shaft about the seven-

teenth year. The anterior part of this epiphysis is intra-synovial, the posterior and larger part is subperiosteal (Fig. 184).

1. **Excision through a Posterior Median Incision.**

Operation.—The patient lies upon the back, with the body close to the edge of the table. The surgeon stands on the side to be operated upon. An assistant is placed on the opposite side of the table—*i.e.*, upon the patient's sound side—and holds the limb. The upper arm should be vertical, or at right angles to the surface of the couch, the elbow should be a little flexed, and the forearm be carried across the patient's chest, so that the elbow projects prominently outwards (Fig. 186). In dealing with the right joint the operator should stand by the patient's loins; and in dealing with the left, well to the outer side of the trunk. A second assistant, standing on the opposite side, can help to steady the limb by grasping the arm and forearm as he leans over the body; and a third helper, placed to the surgeon's left, should be prepared to assist in retracting the divided parts.

Fig. 184.—UPPER END OF THE ULNA IN A SUBJECT AGED 15. (*After Ollier.*)

A, Epiphysis; B, Posterior ligament; C, Anterior ligament.

In this attitude it will be understood that the ulna and olecranon will be uppermost.

The use of the elastic tourniquet should be avoided when possible.

Narrow-bladed rectangular retractors made of the stoutest steel are requisite.

(*a*) The Incision.—The skin incision is about four inches in length, is in the long axis of the forearm, and is so placed as to cross the centre of the olecranon fossa of the humerus, and to run along the middle of the olecranon process, and then follow the crest or posterior border of the ulna (Fig. 185).

The centre of the incision should correspond to the tip or summit of the olecranon, so that two inches of the cut will be over the humerus, and two inches over the olecranon and ulna.

The stout short-bladed excision knife may be carried at once down to the bones, cutting on to the olecranon, bisecting the triceps tendon, opening the articulation through the posterior ligament and reaching the back of the humerus.

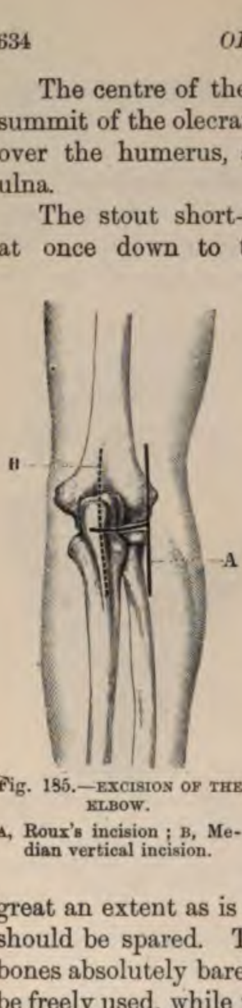

Fig. 185.—EXCISION OF THE ELBOW.
A, Roux's incision ; B, Median vertical incision.

As the cut will be made from "above downwards," it will be seen that in the position occupied by the limb the knife will cut first upon the ulna, which is uppermost, and then upon the humerus (Fig. 186).

(*b*) The Clearing of the Olecranon and the Condyles of the Humerus.—In clearing the bones for excision, the following rules should be observed:—(1) The surgeon should keep the knife well down upon the bone, and his incisions should be short and made with force, and the edge of the blade be kept turned towards the bones. (2) The periosteum should be separated to as great an extent as is possible, and all ligamentous connections should be spared. The operator should aim at leaving the bones absolutely bare. (3) The rugine and the elevator should be freely used, while the knife is employed sparingly. The left thumb-nail must be used with vigour to retract the tissues as soon as they are separated, and the surgeon may expect that the thumb of his left hand will remind him of the operation for many days after. Good retractors must also be employed at every step. The main feature of the operation is the efficient peeling of the olecranon and the irregularly-shaped humerus.

The inner part of the wound is first dealt with.

The inner half of the triceps tendon is peeled from the olecranon with as much periosteum as possible. The hollow

between the olecranon and the internal condyle is now cleared until that process of bone is reached, and is left bare and projecting.

If the operator keep close to the bones, and observe the three rules just laid down, there is no reasonable danger of

Fig. 186.—EXCISION OF THE ELBOW: THE CLEARING OF THE HUMERUS.

wounding the ulnar nerve. The internal lateral ligament is stripped off from both humerus and ulna, and the periosteum is so separated as to carry with it the origin of the flexor muscles.

The surgeon now turns to the outer part of the incision, separating the tissues on that side until the outer condyle is reached and laid bare. In this stage of the operation the outer half of the triceps tendon will be separated and drawn aside without severing its connection with the deep fascia of the forearm, the anconeus will be raised from the ulna, the external lateral ligament and the origin of the mass of extensor muscles will be separated from the humerus, and the supinator brevis will be turned well aside. Here, again, strong retractors are of great service (Fig. 186). It is during this part of the procedure that damage may be done to the posterior interosseous nerve.

The bones of the joint are now free of one another except upon their anterior aspect.

(*c*) The Sawing-off of the End of the Humerus.—The elbow should now be fully flexed, and without much difficulty the lower end of the humerus can be made to project

Fig. 187.—EXCISION OF THE ELBOW: SAWING OF THE HUMERUS. (*Modified from Farabeuf.*)

into the wound. The patient's hand should then be placed in the prone position upon the operating-table, close to the patient's head upon the affected side. In this attitude it can be firmly held, the lower ends of the radius and ulna being fixed rigidly upon the table. The assistant who grasps the upper arm should project the lower end of the humerus

upwards. This portion of bone is now cleared of its few attachments in front, and is bared as high up as is necessary.

The surgeon then grasps the bone with lion forceps held in the left hand, and maintained vertically, as if he would draw the bone directly upwards (Fig. 187).

A narrow saw with a movable back is applied horizontally to the lower extremity of the bone so fixed, and the excision of the humerus is completed.

The saw-line generally crosses the bone at right angles to its long axis, and just below the tips of the condyles.

In using the saw a metal retractor or spatula should be employed to hold back and retract the soft parts.

A strip of bent metal of the form shown in Fig. 187 answers admirably for this purpose.

(*d*) The Sawing-off of the Ends of the Radius and Ulna.—While the limb is in the same position the assistant who is fixing the forearm relaxes his hold, and forcing the bones of that part of the limb upwards, makes them in turn protrude prominently in the wound. The ulna is grasped with the lion forceps, which are again held vertically, as if to draw the bone directly upwards; and the metal spatula having been applied, the saw is applied horizontally to the base of the process, a slice of the upper end of the radius being removed at the same time (Fig. 188).

The wound is washed out, is adjusted with sutures, and a drainage-tube is inserted.

Comment.—The incision here described is that of Park and Maisonneuve, and the operation represents the best method now in vogue for excising the elbow, and the method which—if the selection made by text-books be a criterion—is the most universally adopted.

The operation is simple, the bones are easily exposed on each side, the ulnar nerve is well guarded, the triceps tendon is subjected to the least amount of injury, and efficient drainage is provided for.

The method above described may be considered to follow the open method, although as much periosteum and ligamentous tissue is preserved as is possible, and the operation is of wide application.

The complete subperiosteal excision is described in a chapter which follows.

To preserve the whole of the periosteum is extremely difficult, and often impossible or inadvisable. In the above operation the bone is bared subperiosteally as far as is practical in the great majority of cases.

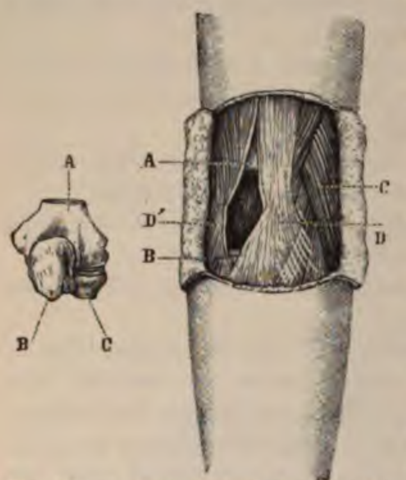

Fig. 188.—A, RIGHT ELBOW AFTER EXCISION BY DORSAL INCISION. (*After Farabeuf.*)

A, Humerus; B, Ulna; C, Supinator longus and radial extensor of the carpus; D, Outer expansion from triceps tendon; D′, Inner expansion from the same.

B, PARTS REMOVED IN THE EXCISION. A, Humerus; B, Ulna; C, Radius.

The projecting end of the ulna may be cut off early in the operation in order that the lower extremity of the humerus might be more easily exposed and dealt with.

2. **The Subperiosteal Method.**

The operation just described is—if it be carried out as detailed—as nearly an example of the subperiosteal method as is in the majority of instances practicable.

The following description is derived from Farabeuf's account of the "Méthode de la Rugine," as distinguished from the "Méthode du Bistouri." (*See* page 603, and Fig. 170.)

Operation.—(*a*) The Incision.—Precisely the same incision is employed as in the last operation. The arm is placed by the patient's side, the elbow is extended, and the hand prone. The elbow rests upon a small, hard, round cushion, which is placed upon the table by the side of the patient's body.

The incision is carried well down to the bones, so as to divide the periosteum both of the humerus and olecranon, to open the joint capsule, and bisect the triceps tendon.

In the position the limb now occupies, the external or radial lip of the wound will be superior, and the internal lip inferior or the nearer to the cushion.

(*b*) Decortication of the Postero-external Parts.—Commencing with the superior or external part of the wound, the surgeon exposes the depths of the original cut, and draws the soft parts well aside by means of proper retractors.

With a rugine and elevator he then proceeds to lay bare the outer part of the olecranon, pressing forwards with the rugine until he has reached the articular surface of the olecranon, and has separated (with the periosteum) the external lateral and annular ligaments and some part of the posterior ligament.

He now turns to the humerus and pares the periosteum from the outer part of the olecranon fossa, and continues the peeling process until he has bared the postero-external part of the humerus and has reached the external condyle. The elbow is now a little flexed, to bring this process better into view, and it is stripped entirely of its periosteum, and of its muscular and ligamentous connections.

With the periosteum the outer part of the posterior ligament will have been elevated and displaced outwards.

(*c*) Decortication of the Postero-internal Parts.—The position of the limb is now changed. The hand is carried upwards beyond the head; the arm is thus close to the face, and the hand, which is supine, is beyond the upper end of the table. The limb is extended, and the cushion again supports the elbow-joint. The wound is now reversed, and the inner lip is uppermost. With the rugine the operator bares the inner surface of the olecranon, clearing off the rest of the triceps and of the posterior ligament. The separation is carried to the inner margin of the articular surface, and the internal lateral ligament is thus peeled off with the periosteum.

The postero-internal surface of the humerus, including the inner part of the olecranon fossa and the internal condyle, are now laid entirely bare. To clear the condyle the joint must be a little flexed.

(*d*) Division of the Humerus.—The joint can now be dislocated, the position of flexion is assumed, and the lower end of the humerus is made to protrude in the wound. The anterior surface of the bone, including the coronoid fossa, is cleared of periosteum, with which is removed also the anterior ligament of the joint.

The extremity of the humerus, being now entirely bare, is seized with lion forceps and sawn through.

(*e*) Division of the Radius and Ulna.—It only now remains to clear the anterior part of the ulna, including the coronoid process, and the neck of the radius, and to saw the exposed bones off, with the precautions already described (Fig. 188).

Comment.—This operation is admirable in theory, but could not often be carried out in its entirety in practice. In some instances, especially in excisions for injury in adults, the decortication would be practically impossible. Especially difficult is it to bare the olecranon and coronoid fossæ of periosteum. In many cases of disease it would be undesirable to save the implicated membrane.

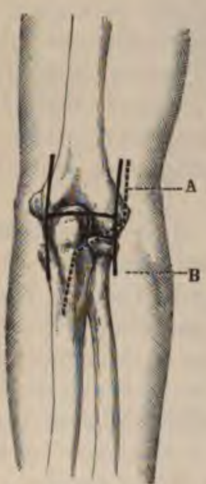

Fig. 189.—EXCISION OF THE ELBOW.

A, Ollier's incision; B H-shaped incision of Moreau.

3. **Other Forms of the Operation.**

The incision most usually employed when the operation was first introduced was the H-*incision of Moreau* (Fig. 189, B).

This was the incision adopted by Syme, Dupuytren, and many others. Jaeger and Liston used the same incision, but omitted the outer vertical limb of the H. Roux in like manner omitted the inner vertical limb (Fig. 185, A). In all the early operations the triceps tendon was cut entirely through.

Subsequent experience has condemned every form of transverse incision in this operation.

Chassaignac employed a longitudinal posterior cut along the outer side of the olecranon, and Langenbeck a like incision along the inner side. These incisions rendered the exposure of one side of the joint very easy, and the laying bare of the other side unduly difficult. They are inferior to the median incision above described.

Two excellent operations by means of lateral incisions remain to be described.

Ollier's Operation by the Bayonet Incision.—The upper part of this incision is vertical, is opposite the interval

between the triceps and the supinator longus, is commenced $2\frac{1}{4}$ inches above the joint-line, and runs down to the tip of the outer condyle.

It is then directed obliquely downwards and inwards to the base of the olecranon, and is finally made to follow the posterior border of the ulna for $1\frac{1}{2}$ to 2 inches (Fig. 189, A).

A vertical incision about one inch in length is made over the internal condyle. Through this small lateral incision the point of the condyle is bared, and the attachment of the internal ligament separated.

Turning to the main wound, and using the rugine rather than the knife, the operator decorticates the external condyle, separating the external lateral ligament, exposes the head of the radius, detaches the triceps tendon together with the periosteum, denudes the olecranon and the margins of the sigmoid cavity, and detaches the insertion of the brachialis anticus.

The bones of the forearm are now luxated forwards, and are divided with a fine saw.

The inner segment of the humerus is in the next place freed of all its attachments, and, the bone being now bare, the saw is applied, and the required section made.

This method has some excellent points. It is, however, needlessly complicated. The triceps tendon is not conveniently exposed, and its important external expansion is divided. The ulnar nerve is less easily dealt with. The wound is large, and not well adapted for drainage. The inner incision is inconveniently placed, and may cause trouble in the after-treatment.

Hueter's operation is a modification of the method just described, and has been considered as especially applicable to cases of excision for anchylosis.

The operation is carried out in the following steps:—

(*a*) The Ulnar Incision and Clearing of the Internal Condyle.—An incision one inch in length is made over the internal condyle and a little to its anterior surface. This cut is carried to the bone, and with a rugine and elevator the periosteum, the internal lateral ligament, and the united tendon of origin of the flexor muscles, are separated from the

bone. The joint is opened. Care must be taken to avoid the ulnar nerve.

(*b*) The Radial Incision and Resection of the Head of the Radius.—The arm is now so placed as to bring the radial side uppermost. The limb is fixed upon a hard cushion in the extended position. The radial cut is about four inches in length. It skirts the outer side of the joint on its posterior aspect.

The centre of the incision is over the external condyle, and the lower part of it over the radius (Fig. 190). With the blunt instruments the periosteum is separated from the outer condyle, together with the tendinous attachments and the external lateral ligament. The orbicular ligament is divided transversely, and the joint is opened from the radial side.

Fig. 190.—EXCISION OF THE ELBOW; LATERAL INCISIONS AS USED IN EXCISION FOR ANCHYLOSIS.

The head of the radius is now free, and is removed by means of a keyhole saw.

(*c*) The Resection of the Humerus.—The finger is introduced into the joint upon the ulnar side while the elbow is flexed. The limits of the anterior part of the capsule are defined, and by means first of the knife and then of the elevator the anterior surface of the humerus is freed as far as possible both of periosteum and ligament.

The elbow is now extended and the posterior part of the capsule made prominent, and the tissues upon this side are in turn peeled from the bone. The lower end of the humerus should by this time be bare, and, the forearm being adducted (*i.e.*, to the ulnar side), this extremity of bone should be made to project through the radial wound. It is grasped with forceps and sawn off. The ulnar nerve should not be seen.

(*d*) The Resection of the Olecranon.—The olecranon is readily brought into view in the radial wound. With the rugine it is stripped of periosteum, and is freed of its connections with the triceps tendon. The upper part of the ulna and the coronoid process are then stripped of their

coverings, and the bone is sawn through just above the base of the coronoid process.

This operation is certainly excellent, and has yielded very admirable results as regards the function of the joint. The procedure is very well adapted for cases of excision for anchylosis. The method is claimed to be subperiosteal. For ordinary purposes Hueter's operation has no advantage over the median dorsal incision.

After-treatment.—After the operation the limb must be placed upon a suitable splint, and the bones so adjusted that the greater diameters of the bony surfaces correspond and do not cross. The hand should be in the mid-position between pronation and supination, and the elbow be very slightly bent—so slightly that the forearm will be nearer to the extended posture than to the position it occupies when at right angles to the arm. The precise angle recommended by most surgeons is an angle of 135°.

Very many forms of splint have been devised. The main requirements of such appliances are that they be light, strong, rigid, easily kept clean, and do not interfere with the drainage and dressing of the wound.

Mason's splint (Fig. 191) answers its purpose well, and also permits the joint to be exercised without the splint being removed. The fingers should be free. The splint and limb may be at first suspended from a cradle, or supported upon a pillow with sand-bags.

It must be borne in mind that there is some disposition for the bones of the forearm to be displaced backward, that too wide a distance between the bones may lead to a flail-like joint, and that if, on the other hand, the sawn surfaces be kept in close contact, in young subjects bony anchylosis may ensue.

In general terms, it may be said that to ensure a false joint the bones should be separated for the distance of half an inch.

After a successful excision by the subperiosteal method in healthy subjects the disposition to anchylosis is considerable. As anchylosis is especially to be feared in children, the limb may be put up from the first on a right-angled splint, such as that recommended for the purpose by Mr. Jacobson (*British Medical Journal*, vol. i., 1877, page 774).

When also a considerable quantity of bone has been removed, the use, from the commencement, of a rectangular splint is advised by many.

Passive movements of the fingers and shoulder, and flexion and extension of the wrist, should be commenced as soon as possible after the operation—possibly by the third day—and should be persevered with daily. Passive movements of the elbow may be commenced about the tenth day, provided that the healing process has proceeded favourably, and the measure can be borne by the patient without undue pain. In children such movements may at first be required to be carried out under an anæsthetic.

Fig. 191.—MASON'S SPLINT FOR EXCISION OF THE ELBOW.

When four or five weeks have elapsed, the forearm may be gradually brought up until it forms a right angle with the arm. At the end of six or eight weeks the splint may be dispensed with, and the movements of the elbow should be free. Active movements, aided by massage and galvanism, should now be advised; and within four months from the time of the operation the new joint should have acquired solidity, and be capable of exhibiting a free and extensive range of movements.

Results.—Excision of the elbow has led on the whole to very satisfactory results, and in a large proportion of the more favourable cases the results have been most admirable. Even if anchylosis occurs at a right angle, the limb is in a better condition than it was while the seat of disease. In the more unfortunate instances the repair is imperfect

for one reason or another, and a very loose false joint, resulting in a flail-like limb, is the final production. Even in such a case a good deal may be done by means of a suitable apparatus.

"In my experience," writes Sir William MacCormac, "the tendency is rather to anchylosis than to increased mobility—at least, after cases excised for disease. The converse may be true in traumatic cases."

Ashhurst's Tables ("Encyclopædia of Surgery," 1884, vol. iv.), dealing with 1,786 cases, give the mortality of excision for gunshot wound as 24·6, for other injury as 15·1, and for disease as 10·6. A large proportion of these cases are not of recent date, and improved methods of treating wounds have served to greatly reduce the mortality.

CHAPTER XIII.

Excision of the Humerus.

Portions of the diaphysis of the humerus have been excised in cases of compound fracture, of bone disease, and of new growths. The most successful operations of this kind have been performed for false joint after fracture, and for badly-united fracture. In gunshot injuries the results have not been favourable. In the American War the mortality attending primary excisions of portions of the humerus was 30 per cent. (Otis).

In acute necrosis in young subjects the whole diaphysis has been removed subperiosteally with admirable results, the bone having been restored to a remarkable degree.

Langenbeck excised the whole of the humerus in a man aged 20 for necrosis following gunshot wound. A mass of new bone filled the place of the original bone, and new joints were formed at the shoulder and elbow. Four years after the operation the arm on the side operated upon was found to have lost only 3¼ inches in length. The patient could execute many movements, although the limb was very feeble.

The humerus is exposed through an incision made upon the outer side of the limb. When the upper part of the shaft is concerned, the cut should be made in the interval between the deltoid and the pectoralis major. When the lower part has to be dealt with, the knife should follow a line which is placed over the insertion of the deltoid, and along the external intermuscular septum. The first care of the operator should be to seek for the musculo-spiral nerve, which is carefully isolated and drawn aside. The bone is conveniently divided with a chain-saw.

CHAPTER XIV.

Excision of the Shoulder.

THE operation known by this name consists really of an excision of the upper end of the humerus. The shoulder-joint is not excised—or, in other words, that portion of the scapula which supports the glenoid fossa is not sawn away with the articular segment of the humerus. Portions of bone may be gouged from the glenoid fossa, but more than that is seldom done. The operation is comparatively rarely performed, and the conditions under which it is carried out are the same as lead to excisions of other joints. In a few instances the upper end of the humerus has been removed for a new growth.

Fig. 192.—EXCISION OF THE SHOULDER: MOREAU'S SQUARE FLAP.

Excision for tubercular joint disease is—in Great Britain, at least—exceedingly rare.

When the operation is performed, the object attained is the establishment of a false joint. The humerus is usually divided through the surgical neck.

In this excision the subperiosteal method is especially to be advised.

Excision of the shoulder was first performed by Bent, of Newcastle, in 1771 (*Philosophical Transactions*, vol. lxiv., page 353, 1774). Orred, of Chester, performed the same operation in 1778 (*Ibid.*, vol. lxix., page 6, 1779). In 1786 Moreau the elder excised the shoulder-joint, literally removing not only the upper end of the humerus, but also such part of the scapula as supported the glenoid fossa, together with part of the acromion.

The operation was warmly supported in Great Britain by Syme, with whom must rest the credit of placing this procedure among the recognised operations of modern surgery.

In the early operations the joint was exposed by raising a flap taken from the deltoid region.

Bent made a flap with the base internal, employing one vertical and two transverse incisions. Moreau's flap had its base inferior (Fig. 192), while the flap devised by Morel had its base superior (Fig. 193, B). Syme employed a posterior flap of somewhat large size. Sabatier's flap was V-shaped.

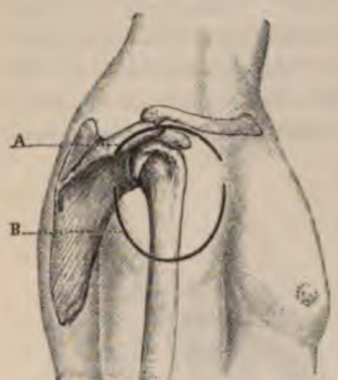

Fig. 193.—EXCISION OF THE SHOULDER. A, Supra-acromial incision (Neudörfer); B, Morel's rounded flap.

The flap operations have been practically abandoned. The credit of introducing the single anterior vertical or oblique incision now in general use is ascribed to Baudens and Malgaigne. Orred, it may be remarked, had used a longitudinal incision from the socket of the shoulder to the insertion of the deltoid.

Chassaignac (1844) appears to have been the first surgeon to advise that the biceps tendon should not be divided.

The perfection of the subperiosteal method is the work of Ollier.

Neudörfer employed a curved incision which, starting from the spine of the scapula, passed over the acromion to the coracoid process. The acromion was sawn through, and the head of the bone thrust out (Fig. 193, A).

Anatomical Points.—The shoulder-joint is very simple in its construction, and the bony points in the vicinity of the joint are easily made out. The part of the humerus felt beneath the deltoid muscle is not the head, but the tuberosities—the greater tuberosity externally, the lesser in front. A considerable portion of the head of the humerus can be felt through the capsule when the fingers are passed high up into the axilla, and the limb is abducted. The head of

the bone faces very much in the direction of the internal condyle.

When the arm hangs at the side, with the palm forwards, the bicipital groove looks directly forwards.

The position of the coraco-acromial ligament may be defined, and a knife thrust through the middle of it would strike the biceps tendon and open the shoulder-joint.

The groove between the pectoralis major and deltoid muscles is usually to be made out. In it run the cephalic vein and a large branch of the acromio-thoracic artery. Near the groove, and a little below the clavicle, the coracoid process may be felt. The process, however, does not actually present in the interval between the two muscles, but is covered by the uppermost fibres of the deltoid.

Fig. 134.—[illegible]

a, Epiphysis; b, Upper part of capsule; c, Lower part of capsule.

The circumflex nerve and posterior circumflex artery cross the humerus in a horizontal line that is about a finger's-breadth above the centre of the deltoid muscle, as measured from the acromion to the deltoid insertion. The artery is usually above the nerve. The point at which these structures cross the humerus about corresponds to the surgical neck.

The capsule of the joint is very lax and is attached to the humerus along the line of the anatomical neck.

The line of the epiphyseal cartilage is shown in Fig. 134. The inner part of the cartilage is just within the capsule; the outer anterior and posterior parts are entirely extracapsular. The epiphysis is united with the shaft at about the age of twenty years.

The surgical neck is situated between the bases of the tuberosities and the insertions of the latissimus dorsi, teres major, and pectoralis major muscles (Fig. 135).

To the greater tuberosity is attached the supra-spinatus, infra-spinatus, and teres minor; to the lesser process the subscapularis.

1. **The Operation by an Anterior Incision.**

The method here described is the "open method." The subperiosteal operation is dealt with in the section which follows.

Operation.—The patient lies upon the back, close to the edge of the table, with the shoulders well raised.

The elbow is flexed, and is carried a little from the side. The assistant who holds the limb sits or stands by the patient's loins. The surgeon takes up a position to the outer side of the shoulder and faces the subject. A second assistant stands behind the shoulder, facing the operator. The bony points about the joint should be defined.

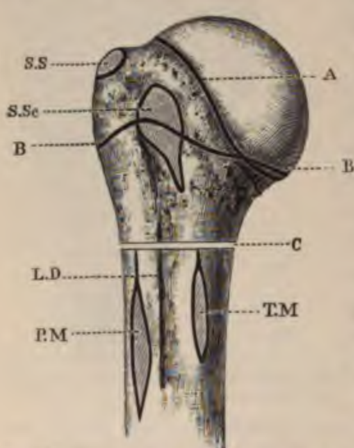

Fig. 195.—DIAGRAM OF THE UPPER END OF THE HUMERUS.

A, Attachment of capsule and anatomical neck; B, Line of epiphysis; C, Surgical neck; S.S, Supra-spinatus; S.SC, Subscapularis; L.D, Latissimus dorsi; P.M, Pectoralis major; T.M, Teres major.

(*a*) The Incision.—The incision, which is three and a half to four inches in length, commences at the outer side of the tip of the coracoid process, and is carried downwards and a little outwards to follow the inclination of the anterior margin of the deltoid muscle (Fig. 196, A).

The knife is carried straight down to the joint, the coraco-acromial arch is exposed, and the capsule of the joint laid bare in the line of the incision. The biceps tendon is next sought for, and the capsular ligament is opened vertically just to the outer side of the tendon. It is most conveniently incised from below upwards.

(*b*) The Separation of the Outer Margin of the Wound.—The operator now proceeds to clear the tissues from the bone upon the outer side of the wound. In the case of the right limb this will be the left margin of the wound, and in the case of the left limb the right margin.

The parts are well retracted with the left thumb, aided when required by retractors. The surgeon uses a blunt-pointed knife, and separates the soft parts from the upper end of the humerus by cutting on to the bone.

The instrument should be kept as close to the bone as possible. As the separation proceeds, the assistant rotates the humerus inwards, while at the same time he depresses the elbow, and forces the head of the bone forwards.

The surgeon clears the capsule from the outer part of the bone, and on reaching the external tuberosity severs the insertions of the supra-spinatus, infra-spinatus, and small teres muscles.

The second assistant aids in retracting the soft parts.

(*c*) The Separation of the Inner Margin of the Wound.—The limb is restored to the position it originally occupied, and the surgeon proceeds to clear the bone upon its inner aspect in the manner just described. The humerus is rotated outwards as he proceeds; and when the lesser tuberosity is reached, the subscapularis insertion is divided and the attachment of the capsule beyond it.

In this stage care must be taken of the biceps tendon, which should be drawn aside.

(*d*) The Clearing of the Neck of the Bone.—The biceps tendon is displaced inwards. The elbow is flexed, and the arm is held vertically (*i.e.*, at right angles to the table), and is thrust upwards so that the head of the bone is made to project through the wound. The posterior part of the neck of the bone is cleared, and the parts prepared for the passage of the saw.

(*e*) The Excision of the Head of the Humerus.—The head of the bone is seized with lion forceps held in the surgeon's left hand, and the bone is sawn through with either a small Butcher's saw or a thin saw with a movable back. The saw-cut should incline from without very slightly downwards and inwards, so that no sharp end may be left which might press upon the axillary vessels or nerves.

In sawing the left humerus the surgeon stands facing the patient, in dealing with the right he will find it more convenient to stand behind the shoulder (by the patient's head). While the saw is being used, the soft parts must be protected by metal spatulæ.

(*f*) The glenoid cavity is examined, a counter-puncture for drainage is made at the posterior and inferior part of the wound, the skin incision is closed with sutures, and the limb placed in position.

Comment.—This procedure can claim to be the best and the most generally-adopted method of excising the shoulder.

The capsule is readily reached, the biceps tendon is easily dealt with and protected from hurt, and no injury is inflicted upon the most important muscle of the shoulder—the deltoid. The wound is not well adapted for drainage, a defect met by the counter-puncture just described. The incision described is that of Baudens, Hueter, and Ollier.

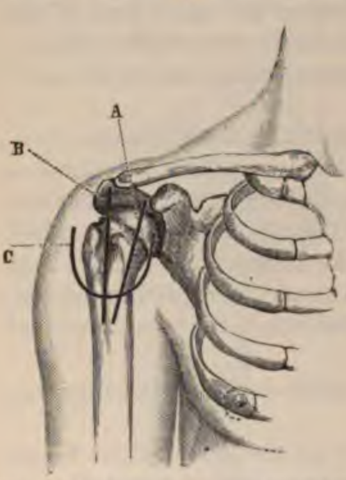

Fig. 196.—EXCISION OF THE SHOULDER. A, Incisions of Baudens, Hueter, and Ollier; B, Vertical incision of Langenbeck and others; C, Morel's incision.

Langenbeck's incision is placed more to the outer side, and has for its starting-point the acromio-clavicular joint (Fig. 196, B). No especial advantage appears to have been claimed for a skin wound so placed, while it has the disadvantage of inflicting more serious damage upon the deltoid muscle.

In operating upon the left side it may be more convenient to clear the left side of the wound first.

As little bone should be removed as is possible. In some instances it may be practicable to make the section at the anatomical neck. It will obviously be a great gain if either of the tuberosities can be saved. The higher the saw-cut, the wider the section.

In children only very little of the bone can be removed without taking away the whole of the epiphysis.

So far as the growth of the arm is concerned, this is the most important epiphysis in the limb.

Some surgeons have advised that the bone be sawn *in*

situ—*i.e.*, that the head be not protruded through the wound. This method, however, is less precise, little opportunity is given of fully examining the part, and the tissues around may be damaged by the saw. If the bone be divided *in situ*, a chain-saw should be employed.

2. **The Subperiosteal Operation.**

The patient is placed in the same position as in the last operation. The arm lies by the side. The same incision is made. The capsule is exposed, and the biceps tendon discovered.

The capsule is incised vertically to the outer side of the biceps tendon, and the incision is carried downwards through the periosteum on the neck of the bone as far as the intended saw-cut. The knife is now laid aside for the rugine and elevator. Commencing at the outer segment of the wound, the surgeon separates all the soft parts from the bone, detaching the periosteum, the capsular ligament, and the muscular insertions in one continuous and unbroken layer. The rugine is worked upwards and downwards. The arm is rotated inwards gradually, and is at the same time abducted, and the head of the bone pushed upwards and forwards. The greater tuberosity is reached and cleared, and the bone freed as far as possible beyond it. In clearing the outer part of the humerus, the surgeon should stand facing the patient while dealing with the right limb, and behind the shoulder—*i.e.*, close to the head—while treating the left limb.

In the process the thumb and suitable steel retractors must be vigorously employed to draw back the separated tissues.

The next step consists of clearing the lesser tuberosity, and the inner part of the neck of the bone. Like measures are adopted. As the surgeon progresses, the limb is rotated outwards, the arm is adducted, and the head of the humerus is thrust upwards and forwards.

In this part of the operation the surgeon stands facing the patient when excising the left bone, and behind the shoulder when operating upon the right side.

The head of the bone is now thrust out of the wound, and the neck is cleared of any remaining ligamentous or periosteal attachments.

The excision of the head is carried out in the manner already described.

Comment.—This operation differs from the last only in the essential particular that the bone is laid entirely bare.

The method is of course not always practicable, and sometimes not advisable; but whenever it is possible, it should be carried out. The results which have been obtained by the subperiosteal method are infinitely superior, so far as function is concerned, to those which follow the open method. The attachments of the rotator muscles are saved, and the continuity of the capsule with the periosteum of the shaft of the bone is preserved. The actual amount of periosteum saved is not considerable.

3. **Other Methods.**

1. *The Deltoid Flap.*—The chief forms of deltoid flap which have been from time to time made use of, have been already described in the introductory paragraphs. This form of operation would appear to be now abandoned. It has the advantages of being easy of performance, and of well exposing the parts of the joint. It has the overwhelming disadvantage of destroying the function of the deltoid muscle. It is conceivable that the operation might still be carried out in some cases of new growth, *e.g.*, a large enchondroma involving the upper end of the bone, for the removal of which considerable space would be required.

2. *The Posterior Incision.*—Sir William MacCormac considers that this method may be carried out when it is not necessary to divide the bone below the tuberosities, and describes the operation in the following words :—

"The patient must be placed on the sound side, the arm flexed at the elbow, somewhat abducted and rotated outwards, so that the external condyle looks backwards. This brings the middle of the great tuberosity into the line of the wound. A vertical incision is then made downwards for about four inches from the prominent angular projection so plainly felt on the inferior margin of the acromion (Fig. 197). The posterior part of the deltoid is divided, and the knife at once sunk into the capsule beneath the acromion. The great tuberosity and the bicipital groove just in front of it may now be brought

within the area of the wound, and the muscles attached to the tuberosity can be separated. The rotation outwards of the arm being continued, the elevator is used to raise the periosteum and capsule till the bicipital groove is reached, when the biceps tendon is dislodged. Then the arm must be strongly rotated inwards, and the subscapularis muscle at its insertion will come into view. This is separated in a similar manner from the lesser tuberosity. The head may now be made to project from the wound, and by rotating alternately outwards and inwards any remaining soft parts or capsule may be divided on the anterior and axillary margins of the wound, the head fully luxated and removed. The trunk of the circumflex nerve will in this case be cut through, and no active abduction can afterwards be expected. Through the posterior incision the glenoid cavity, if need be, can be much more easily removed than through the anterior wound."

Fig. 197.—EXCISION OF SHOULDER: POSTERIOR INCISION.

Except in so far that good drainage is provided for, and that the glenoid process can be more readily dealt with, this operation is in every way inferior to the method by the anterior incision.

After-treatment.—The upper end of the humerus is to be brought into contact with the glenoid fossa. The arm is secured to the side, the hand rests in a sling. A large pad of cotton-wool is introduced into the axilla. This pad is intended to support the bone, to assist in fixing the parts, and to counteract the tendency which will be exhibited for the upper end of the humerus to be drawn inwards under the coracoid process. This displacement is especially apt to occur when the external rotator muscles have been divided, and there is little to withstand the action of the pectoralis major and latissimus dorsi. The size of the pad must be regulated

according to the needs of the case. It should be of triangular outline, with the base uppermost.

The pad is likely to fail, if it fail at all, from being too small rather than too large. No splint is required.

Passive movements of the fingers, wrist, and elbow, may be commenced within a day or two of the operation. Very gentle passive movements of the shoulder may be first attempted at the end of some fourteen days. These movements should consist of flexion and extension, of slight rotation, and of still slighter abduction. The latter position tends to throw the end of the bone inwards—or, rather, to assist the disposition to that deviation. Massage, electricity, and active movements will follow in due course. The arm may be allowed to hang, with no other support than a sling, at the end of some four or five weeks.

Results.—The results of this operation may be considered to be very satisfactory. Culbertson, dealing with 115 cases of excision for disease, shows that the mortality has been only 18·2 per cent., a result which compares very favourably with the mortality after amputation at the shoulder-joint.

There is no doubt that increasing care in the selection of cases, and more precise measures for treating wounds, have led to a substantial reduction in the mortality as given by Culbertson in 1876. More than two-thirds of the subjects of the operation appear to recover, with quite useful limbs. In many instances the restoration of function has been remarkable. As a rule flexion and extension are freely performed, and the patient can lift considerable weights.

Adduction also is well accomplished. On the other hand, rotation movements and abduction are feebly performed.

The arm cannot be lifted beyond a right angle with the trunk. It is after the subperiosteal operations that the best results have been obtained, and some of Ollier's cases show a very remarkable restoration of function.

There is a tendency, as already stated, for the upper end of the bone to assume the position occupied by the head in sub-coracoid dislocation. Anchylosis appears to result more frequently than a flail-like joint.

CHAPTER XV.

EXCISION OF THE CLAVICLE AND SCAPULA.

THE CLAVICLE.

THE clavicle has frequently been removed in whole or in part. The conditions for which the operation has been performed are caries, necrosis, tumour, severe injury (*e.g.*, gunshot wound), and irreducible dislocation of the inner end of the bone, causing pressure symptoms.

The first operation for the complete removal of the clavicle appears to have been performed by McCreary, of Kentucky, in 1811, for necrosis (Johnson, *Med. and Surg. Journ.*, vol. vi., page 474, 1850).

Anatomical Points.—The general anatomy of the clavicle need not be given in detail in this place.

The bone is superficial, and is crossed in front by the supra-clavicular nerves, and a small vein which connects the cephalic with the external jugular.

The main ligaments that hold the bone in place are the conoid, the trapezoid, the rhomboid, and the inter-clavicular.

The extent of the attachment of the great muscles—the deltoid, the trapezius, the pectoralis major, and the sterno-mastoid—must be borne in mind.

The two curves of the bone meet at the junction of the middle with the outer third, and it is here that the bone is the most slender.

The clavicle begins to ossify before any long bone in the body, and at birth the entire shaft is bony, the two ends being still cartilaginous. There is one epiphysis—a mere shell—for the sternal end. It appears between the eighteenth and twentieth years, and joins the shaft at twenty-five.

Beneath the clavicle the great vessels and the great nerve-cords lie upon the first rib. The vein is the most internal,

and occupies the acute angle between the collar-bone and the first rib. Between these structures and the bone is interposed the subclavius muscle and the dense fascia which surrounds it. This muscle is of great service in the operation, and affords a substantial protection to the parts beneath.

Behind the clavicle the following structures may be noted:—The innominate, subclavian, and external jugular veins; the subclavian, supra-scapular, and internal mammary arteries; the cords of the brachial plexus; the phrenic nerve and nerve of Bell; the thoracic duct; the omo-hyoid, scalene, sterno-hyoid, and sterno-thyroid muscles; the pleura and the apex of the lung.

Operation.—The patient is placed in the position advised in ligaturing the third part of the subclavian artery, and the surgeon stands upon the affected side. The excision knife should be small and blunt-pointed.

An incision is made along the whole length of the bone—when entire excision is intended—and extends beyond it over the sterno-clavicular and acromio-clavicular joints.

The bone is carefully cleared of all its soft parts upon the superior and anterior aspects.

If the case be suited for the subperiosteal method, the rugine may be employed to lay the bone bare.

A way should be made immediately behind the bone at the junction of the outer with the middle thirds, and at this point a chain-saw should be passed around the clavicle with the usual precautions.

When the bone has been divided, the inner end of the acromial segment is seized with lion forceps, and is drawn forwards with the left hand, while with the right the surgeon clears it upon its inferior and posterior aspects. When the acromial part has been removed, the sternal segment is seized and dealt with in like manner. It is the removal of this portion of the bone that involves the chief element of risk in the operation.

Throughout the whole of the excision the greatest care must be taken to keep the knife close to the bone, to cut always on the bone, to be equally cautious with the rugine, and to use spatulæ and retractors, so as to protect the soft parts in the event of the instrument slipping.

After the excision the wound is closed with sutures, and the limb is adjusted as in the treatment of fracture of the clavicle.

Comment.—The above description can give little idea of this excision, and an operation upon the cadaver can afford little conception of the procedure as it is carried out in practice.

In dealing with the living subject the parts will be so modified and disturbed by injury or disease that the lines of a formal operation cannot be recognised.

Those who have carried out excision of the clavicle only on the cadaver can hardly realise that in Mott's well-known case the operation occupied four hours, and over thirty ligatures were applied. The patient was a lad of nineteen, and the excision was for a new growth. An excellent recovery resulted (*Amer. Journ. Med. Sci.*, vol. iii., O.S., page 100, 1828).

The operation is usually attended with much bleeding; and the nearer the subperiosteal method can be adhered to the less will this be in amount.

The large veins in the vicinity of the bone are exposed to great risk, and have been both wounded and torn. Another great danger depends upon the entrance of air into divided veins.

There is risk of wounding the pleura, of tearing the thoracic duct, and of injuring some of the important nerves which are close to the sternal end of the bone.

A key-saw may be used in the place of the chain-saw.

Results.—Ashhurst has collected 28 examples of excision of the entire clavicle. The operation was performed 16 times for caries or necrosis, 9 times for tumour, and 3 times for injury. Six patients died, and 22 recovered.

Among 74 examples of partial excision of the bone, only 10 deaths are recorded.

THE SCAPULA.

In the larger number of cases of excision of this bone the operation has been performed for tumour. Excision has also been carried out in the treatment of caries or necrosis, and for severe injury.

In the greater proportion of the instances the excision has been partial.

Partial excisions, such as concern the removal of the acromion, or of portions of the spine for necrosis, hardly come under the present category. These operations involve little more than the removal of sequestra.

Liston in 1819 removed about three-fourths of the scapula for tumour, leaving the glenoid cavity and the processes ("Elements of Surgery," 2nd ed., page 190).

Luke in 1828 performed an operation of like magnitude, also for tumour (*Lond. Med. Gaz.*, 1830, vol. v.).

The first operation for the removal of the entire bone is ascribed to Langenbeck in 1855 (*Deutsche Klinik*, 1855).

Anatomical Points.—The precise attachment of the various scapular muscles must be borne in mind.

It is well to note also the dense fascia which covers and binds down the muscles of the supra-spinous and infra-spinous regions.

The exact attachments of the capsular ligament, of the conoid and trapezoid ligaments, and of the coraco-humeral ligament, are material to this operation.

The importance of saving the glenoid segment of the bone, and the acromion and coracoid processes will be obvious.

A line drawn from the supra-scapular notch through the great scapular notch marks the site of the surgical neck of the bone, and isolates the glenoid cavity and coracoid process. The periosteum is thick and strong over the spine, the acromion and coracoid processes, and along the borders.

The epiphysis which forms the acromion joins the main bone at nineteen; that which forms the coracoid, at about fourteen.

Nutrient branches from the subscapular artery pierce the concave surface of the bone, while like vessels from the suprascapular artery enter foramina in both the supra-spinous and infra-spinous fossæ.

The main vessels to be noted in connection with the operation are—(1) the supra-scapular, at the superior border of the bone, where it crosses over the ligament of the suprascapular notch; (2) the posterior scapular, which follows the vertebral border of the bone under cover of the rhomboids;

(3) the subscapular, which runs along the lower border of the subscapularis muscle to reach the inferior angle; (4) the dorsalis scapulæ, which crosses the axillary border of the bone to enter the infra-spinous fossa; and (5) the acromial branches of the acromio-thoracic artery which ramify about the acromion process.

The largest of these vessels are the dorsalis scapulæ and the subscapular. The former vessel crosses the axillary border of the scapula at a point on a level with the centre of the vertical axis of the deltoid muscle.

Operation.—The patient lies close to the edge of the table, and upon the sound side. The back of the scapula is well exposed. The following incisions are made:—One follows the vertebral border of the bone from the superior to the inferior angle; it is to the outer side of the border, and is parallel with it. A second incision commences over the acromio-clavicular joint, and is carried along the acromion and spine to meet the first incision at a right angle.

Two flaps are thus formed—an upper and a lower one. The operation is carried out in the following steps:—

1. The upper flap is first turned up, and the trapezius muscle is divided along its line of attachment to the bone.

2. The lower flap is turned down, and the deltoid muscle is in like manner divided at its insertion.

3. The patient's hand is drawn as far as possible over the shoulder of the sound side, to bring into prominence the vertebral border.

All the muscles attached to this border are severed close to the bone. The posterior scapular artery is ligatured.

The free edge of the scapula is dragged towards the operator, and the serratus magnus is cut through.

4. While the limb is still in the same position the superior border of the bone is cleared and the supra-scapular artery is ligatured.

5. The patient's hand is now dragged down towards the hip. The acromio-clavicular joint is opened. Any remaining attachments of the deltoid and trapezius are divided. The conoid and trapezoid ligaments are cut from behind, close to the clavicle.

The limb is so manipulated that the coracoid process is

turned towards the operator. The muscles attached to it (biceps, coraco-brachialis, pectoralis minor) and the remaining ligamentous fibres are divided.

6. The capsule is divided with the muscles around it, viz., the supra-spinatus, infra-spinatus, and subscapularis. The scapular heads of the biceps and triceps are cut. The bone is now only connected by means of its axillary border.

7. The muscles of the axillary border—the teres major and minor—are divided near to the scapula.

The subscapular artery is sought for and ligatured.

The scapula is at this last stage in such a position that the muscles may be cut from before backwards, and the trunk of the subscapular artery may be exposed before it gives off the dorsalis scapulæ.

Comment.—The steps of the operation need not follow the above course, but may be varied as found most convenient. It is very desirable, however, that the muscles of the axillary border, and the subscapular artery, should be left to the last.

The great risk throughout the operation is from hæmorrhage; and as the excision is most usually carried out for a sarcomatous growth, the vessels are numerous and of large size. It is essential that compression of the subclavian artery be maintained, and, if necessary, a special incision may be made over that vessel in order that it may be more conveniently reached.

The main vessels may be exposed and ligatured before they are cut. The other bleeding arteries must be clamped as divided.

"Division of the clavicle," writes MacCormac, "with a small saw just internal to the conoid ligament increases the facility with which the later steps of the operation may be completed, for then time is not lost in detaching the outer extremity of the clavicle from its connections with the scapula."

It is assumed in the above description that the operation is performed for tumour, and consequently the deeper muscles of the scapula—namely, the subscapularis, supra-spinatus, and infra-spinatus—are removed with the bone, their tendons of insertion alone being left.

The subperiosteal method has been advised in performing

this excision. It may possibly be carried out when dealing with some small portion of the bone—as when the operation is performed for limited necrosis or caries—but in the great majority of instances, and certainly in all operations for tumour, the method is entirely out of place.

The procedure is slow and tedious, and enormous masses of quite useless muscle are left attached to the humerus. If the excision be for a growth, the more completely the bone is removed the better.

Mr. Pollock (*St. George's Hospital Reports*, vol. iv., page 236) has pointed out that in dealing with cases of new growth the removal of a part of the scapula is a less satisfactory proceeding than the removal of the whole.

"If a portion of the scapula be removed, it should only be the lower portion. But even if this be attempted, the loss of blood would probably be much greater than if the whole bone were removed; for the wound is more confined, and the wounded arteries are more apt to retract behind the bone above, and offer great obstacles to their being secured. However, should the lower angle be alone the seat of disease, the attempt to remove the lower portion only is justifiable. . . . As the removal of the whole bone is not a more formidable operation than the removal of a portion of it, and as the patient has less chance of a recurrence of his disease if the whole bone be taken away, it should be in a very exceptional case, and on some very peculiar merits of its own, that the surgeon ought to undertake the removal of a portion of the scapula."

The instances, however, are not few in which the glenoid cavity may be saved.

After-treatment.—A drain should be introduced into the lower part of the wound for the first 24 or 48 hours. The patient must occupy the recumbent position, with the shoulder and upper limb secured upon a pillow. As soon as healing is sound, the limb may be supported in a sling.

Results.—The utility of the limb preserved is often remarkable. Patients have recovered with considerable power in the extremity, have been able to lift weights and follow a light occupation.

In Mr. Symond's case (*Clin. Soc. Trans.*, vol. xx., page 24)

the patient was able to do all the lighter work of a carpenter, including the use of a plane. Overhead work he could not manage.

Ashhurst has collected 42 examples of removal of the entire scapula. In 2 the result is unknown; 32 recovered, and 8 died—a mortality of 20 per cent.

CHAPTER XVI.

Excisions of the Toes, Metatarsus, and Tarsus.

The general as well as the detailed observations that apply to the fingers and metacarpus, apply also to the corresponding parts of the foot.

These operations are but very rarely indeed carried out, and not a few of the procedures described in the more formal text-books have no real existence in practice.

Fig. 198.—Excision of first metatarsal bone.

A great proportion of the cases for which excision has been advised are more properly treated by amputation, or by some other measure.

The importance of the great toe in the general mechanism of the foot is fully recognised, and the principal excision operations that would be considered under the present heading have reference to that digit.

The metatarso-phalangeal joint of the great toe has been excised for suppuration of the articulation, following abscess of a bunion. The same joint has also been excised for the relief of hallux valgus (*see* osteotomy for this deformity), and the inter-phalangeal joint of the second toe has been excised to remedy the mal-position of hammer-toe.

The removal of individual metatarsal bones for disease cannot be said to have been attended with satisfactory results.

The metatarsal bones and phalanges agree respectively with the corresponding bones of the hand in the mode and time of their ossification.

The operations upon the various bones and joints are carried out in the foot upon similar lines to those already described in connection with the hand.

The two principal methods of excising the metatarsal bone of the great toe are shown in Figs. 198 and 199.

EXCISION OF CERTAIN BONES OF THE TARSUS.

Mickulicz's osteo-plastic resection of the foot is described in the chapter on amputations (page 456).

Cuneiform osteotomy of the foot is dealt with in the chapter on osteotomy (page 580).

Excision of certain individual bones of the tarsus is occasionally practised. The operations concern mainly the astragalus and the os calcis.

Fig. 199.—EXCISION OF FIRST METATARSAL BONE: FLAP METHOD.

The cuboid has been removed in the treatment of severe forms of talipes. (*See* Osteotomy of the Foot, page 580.)

Other of the tarsal bones have been removed—or, more accurately speaking, gouged out—through a simple incision, in cases of limited disease.

The Synovial Membranes of the Foot.—In dealing with individual bones of the tarsus, the position and extent of the synovial membranes of the tarsal joints must be borne in mind.

The following are the synovial cavities of the ankle and tarsal joints (Fig. 200):—1. The synovial membrane of the ankle-joint. 2. A sac between the posterior parts of the os calcis and astragalus, behind the interosseous ligament. (Not shown in Fig. 200.) 3. A sac of synovial membrane which is interposed between the anterior parts of the os calcis and astragalus, in front of the interosseous membrane, and between the head of the astragalus and the scaphoid. 4. A

synovial membrane between the os calcis and the cuboid. 5. One between the external cuneiform and the cuboid. 6. One between the cuboid and the fourth and fifth metatarsal bones. 7. A sac which separates the internal cuneiform from the first metatarsal bone. 8. A large and most irregular synovial membrane which is insinuated between the remaining bones of the foot, and serves to connect many articulations.

Fig. 200.—THE ARTICULATIONS OF THE FOOT.

1. **The Astragalus.**

This bone has been excised for disease, especially for caries following injury in healthy subjects, for gunshot injuries of limited extent, for irreducible or unreduced dislocations of the bone, and for the relief of some forms of intractable talipes.

Anatomical Points. — The bone is in relation with the synovial membrane of the ankle, with that separating the os calcis from the astragalus behind the interosseous ligament, and with that interposed between these two bones in front of the ligament, and between the posterior part of the scaphoid and the astragalus.

The head of the astragalus lies in a socket formed by the scaphoid, the anterior concave facet on the sustentaculum tali, and the inferior calcaneo-scaphoid ligament. This powerful ligament is covered with fibro-cartilage upon its upper surface.

The most important ligament actually attached to the astragalus is the interosseous, which passes between it and the os calcis.

No muscles are connected with this bone.

The astragalus begins to ossify about the seventh month of fœtal life. By the third year the bone will be about half bone

and half cartilage. The osseous tissue occupies the centre, the cartilaginous tissue the surface or periphery.

The dorsalis pedis artery crosses in front of the bone.

The bone is most conveniently reached on the inner side between the tendons of the tibialis anticus and the tibialis posticus, and on the outer side between the tendons of the peroneus tertius and peroneus brevis.

Advantage is taken of these two spaces in the operation which follows :—

Operation.—The patient lies upon the back, and the foot is so placed as to extend beyond the end of the table. It must be held by an assistant, who can manipulate it as directed.

Two incisions, external and internal, are made. The outer incision is about two and a half inches in length, runs parallel with and just posterior to the tendon of the peroneus tertius, and commences a line or so above the level of the articular margin of the tibia (Fig. 201, A).

Fig. 201.—A, Excision of astragalus (outer incision); B, Excision of ankle (outer incision); C, Excision of os calcis.

A second and much shorter cut starts from the centre of the principal incision, is placed at right angles to it, and ends immediately below the tip of the outer malleolus. The two slight flaps thus defined are turned aside, and the bone exposed in the interval between the peroneus tertius and peroneus brevis tendons.

The foot is well extended and inverted, and the ligaments which connect the bone with the fibula, tibia, scaphoid, and os calcis, are divided so far as they can be reached from the outer side. Retractors are used to protect the tendons, etc.

The inner incision is about two inches in length, and, start-

ing from just below the tip of the inner malleolus, is carried forwards and upwards just in front of the anterior margin of that bone. It will be curved therefore, with the concavity backwards (Fig. 202, A).

The remaining ligaments that hold the astragalus are now divided from the inner side.

The surgeon turns finally to the outer wound, and, while the foot is inverted and extended, grasps the astragalus with lion forceps in a vertical direction, and, as Farabeuf expresses it, "whips it out like a molar."

The wound will need to be drained, and the limb to be firmly secured upon a splint or in plaster of Paris, with the foot at right angles to the leg.

Excellent results have followed. A useful but somewhat shortened extremity is produced, and no movement will probably be restored to the ankle-joint.

Some surgeons carry out the excision of the bone through a single external wound.

The method of operating through a transverse dorsal incision with division—and subsequent suture—of the anterior tendons has little to recommend it.

2. **The Os Calcis.**

This bone has been removed for disease, and in some cases of injury. The arrangement of the synovial membranes in relation with the bone is such that mischief commencing in the os calcis is apt to be limited to it.

Anatomical Points.—Three synovial membranes are connected with the surfaces of this bone.

From the upper surface of the os calcis arises the extensor brevis digitorum, and from the plantar surface the first layer of the plantar muscles.

Many strong ligaments are attached to the calcaneum, the most noteworthy being the interosseous, the inferior calcaneo-scaphoid, the long and short plantar, and the prolongations of the lateral ligaments of the ankle-joint.

The principal nucleus of the os calcis appears in the sixth month of fœtal life. Before the age of ten years the posterior part of the bone is wholly cartilaginous. A nucleus appears at that date in this cartilaginous segment, and the epiphysis so formed is united to the rest of the bone about the sixteenth

year. The bloodvessels of the bone enter mainly from the inner side.

Operation.—Among the many methods devised for the excision of this bone, the procedure described by Farabeuf appears to be upon the whole the best. The incision he recommends is a combination of the horse-shoe incision employed by Erichsen, and the simpler skin-cut made use of by Ollier.

The operation should be performed as far as is possible by the subperiosteal method.

The patient lies upon the sound side, the leg is supported upon a sand pillow, and the foot, turned well upon its inner border, is free.

The incision, commencing at the base of the fifth metatarsal bone, is carried horizontally backwards just above the margin of the sole, and, passing round the hinder aspect of the heel, ends about one inch and a quarter to the inner side of the median line (Fig. 201, C).

This cut is met by a vertical incision two inches in length, which is parallel to and a little in front of the tendo Achillis. The wound is deepened, and two small flaps are formed. Great care must be taken of the peronei tendons, to which the vertical incision is posterior. The bone is exposed behind the peronei tendons, and the periosteum is incised vertically. With a rugine the periosteum and the associated ligaments are separated from the bone. The outer surface is cleared first, then the posterior surface. The attachment of the tendo Achillis is severed. The foot being placed in the position of talipes varus, the posterior aspect is bared of periosteum as far as it is possible to reach. The anterior portion of the bone is cleared, and the ligaments separated with the periosteum. The same is done with the plantar surface. A certain part of the inner surface can be reached from the posterior aspect.

With care and patience and the use of good retractors the greater part of the bone can be bared through this outer incision, and from this side also the interosseous ligament can be reached and divided.

When the os calcis is as far freed as possible, the head or anterior part must be grasped with lion forceps, and the bone dragged outwards with a repeated rotatory movement, the periosteum and ligaments upon the inner surface being

separated with the rugine as soon as each part of the as-yet-untouched district is reached.

Comment.—This operation can be performed upon the cadaver in the systematic manner just described, but in practice so formal a procedure can seldom be carried out.

Sinuses may have to be considered, and carious and broken-down bone to be dealt with. A not inconsiderable part of the bone, in cases of disease, may be removed with the gouge or sharp spoon, and such parts of the compact tissue as are healthy may be left as a kind of thin osseous mould.

The operations which are characterised by the formation of a U-shaped plantar flap are to be condemned, on account of the unnecessary damage they inflict upon the tissues of the sole.

In an operation carried out by Mr. Holmes ("System of Surgery," vol. iii., page 771) the peronei tendons are divided, a step which has little to recommend it.

The foot must be fixed at a right angle with the leg, and the heel allowed to be free.

An anterior well-moulded metal splint answers the purpose well. After the splint has been applied, the limb must be suspended in a suitable apparatus.

This protects the foot from any pressure, and allows efficient drainage to be carried out.

The results obtained from this operation have been most satisfactory. According to Vincent's statistics, 64·7 per cent. of those operated on have recovered with useful limb, while only 5 per cent. have died.

CHAPTER XVII.

Excision of the Ankle.

This excision is of but limited application, and is comparatively rarely performed. In the first place, the modern improvements in the methods of treating wounds are such that a large proportion of the cases of disease of the joint yield to simple surgical measures. Those who advocate the excision of the joint for disease urge that it should be performed early; but probably the majority of surgeons would prefer to defer any radical measure until treatment by rest, drainage, and favourable hygienic conditions had been tried.

In the second place, amputation of the foot leads to very admirable results, and the excision of the ankle must have a very happy termination if it can yield a more useful extremity than that left after a successful Syme's amputation.

In not a few cases the disease has extended so far beyond the actual area of the ankle-joint that the operation of excision could not be entertained.

The after-treatment of these excision cases is difficult and anxious, and demands infinite and long-continued care. This circumstance in itself affords a substantial objection to the operation.

The ankle has been excised in many cases of injury, notably in compound dislocation and in instances of complex fracture. Here, also, the position of this class of case has been very materially altered by the modern methods of wound treatment, and many a foot which twenty years ago would have been amputated or treated by excision is now saved.

The excision of the ankle to remedy deformity resulting from malunited fracture—*e.g.*, severe Potts's fracture—is in the present day usually replaced by a linear or cuneiform osteotomy.

During the last five years no excision of the ankle has

been performed at the London Hospital, and examples of the operation have mostly to be sought for among older records.

In dealing with excision of the ankle for disease Mr. Howard Marsh writes: "It is but seldom performed; and when it is performed, the result is usually unsatisfactory."

The first excision of the ankle was carried out by Moreau in 1792. The patient was the subject of caries, and an excellent result followed.

The first operation of this kind performed in England was undertaken in 1851 by Mr. Hancock.

For some twenty years following this date a considerable number of excisions of the ankle were performed.

Anatomical Points.—The ankle-joint forms a very powerful articulation, its strength being derived not only from the shape of its component bones, but also from the unyielding ligaments and the many tendons which are bound about it like straps. Of the ligaments, the two lateral are very strong, and have an extensive hold upon the foot. The anterior and posterior are, on the other hand, extremely thin and insignificant, although the latter is supported by the tendon of the flexor longus pollicis, which crosses it.

The loose synovial sac of the ankle-joint extends, both in front and behind, beyond the limits of the articulation, while at the sides it is strictly limited to the joint surfaces. The ankle is a perfect hinge-joint, and permits only of flexion and extension.

The outlines of the two malleoli can be distinctly defined. The external is somewhat the less prominent, descends lower, and lies farther back than the internal process.

The tip of the outer malleolus is about half an inch behind and below the tip of the corresponding bony prominence.

The head of the astragalus can be made out upon the dorsum of the foot when the limb is fully extended.

About one inch and a quarter in front of the inner malleolus the tubercle of the scaphoid can be felt. Just behind it is the astragalo-scaphoid joint.

On the outer side of the foot the external surface of the os calcis is subcutaneous in nearly the whole of its extent. Less than an inch below and in front of the malleolus is the peroneal tubercle, with the short peroneal tendon above it,

and the long one below it. The ankle-joint lies about on the level of a point half an inch above the tip of the inner malleolus.

The position of the tendons about the ankle-joint must be borne in mind, as also the situation of the tibial and peroneal arteries.

The lower epiphysis of the tibia includes the articular surface and the internal malleolus. Ossification commences in it during the second year, and the epiphysis joins the shaft between the eighteenth and nineteenth years. The lower epiphysis of the fibula includes the articular surface and outer malleolus. Ossification commences in the second year, and is completed about the twenty-first year. Both epiphyseal lines are horizontal, and are brought in contact with that pouch of synovial membrane which extends upwards between the tibia and fibula.

Operation.—The various methods in vogue for performing this operation are, for the most part, modifications of the original procedure of Moreau. Indeed, no very conspicuous deviations from the initial operation have been proposed or carried out. Of the modern forms of Moreau's operation, that by Langenbeck would appear to be one of the best. It may be carried out as follows, if the subperiosteal method be attempted:—

The patient lies upon the back, with the foot and leg supported upon a firm sand pillow. Two vertical lateral incisions are made.

1. *The Outer Incision.*—The foot being turned over upon its inner side, a vertical incision some three inches in length is made along the anterior part of the fibula to a point a little below the tip of the malleolus. Thence it is made to curve around the malleolus, and ascend for about one inch along its posterior border (Fig. 201, B).

2. *The Removal of the Fibula.*—The fibula is exposed, and its periosteum divided in the long axis of the bone. The membrane is then separated from the bone by the rugine in an anterior and a posterior direction.

The ligaments attached to the malleolus are separated as encountered. The external lateral ligament is divided vertically, so that its anterior segment will go with the

anterior layer of separated periosteum, and its hinder segment with the posterior layer.

With the curved rugine the greater part of the circumference of the shaft of the bone can be bared about the saw-line.

The fibula is then divided with either a chisel or a saw about one inch above its extremity. The divided end is seized with lion forceps, or is drawn outwards with a hook, while its deeper connections are separated with the rugine, aided by the knife.

This part of the operation is very tedious.

The lower end of the fibula is thus removed.

3. *The Clearing of the Tibia.*—As much of the anterior and posterior surfaces of the tibia as can be reached through the outer cut are bared of periosteum by means of the rugine, the anterior and posterior ligaments of the ankle being elevated with the periosteal layers. In this part of the operation, care must be taken not to open the sheaths of the tendons.

Fig. 202.—A, Excision of astragalus (inner incision); B, Excision of ankle (inner incision).

4. *The Inner Incision.*—The foot is turned upon its outer side, and an incision about three inches long is made along the inner surface of the tibia, and in the long axis of the bone. The cut ends at the tip of the inner malleolus. A curved or transverse incision (Fig. 202, B) may be made to meet the lower end of this wound at right angles.

5. *The Removal of the Tibia.*—The periosteum of the tibia is incised vertically, and that membrane is peeled from the bone so that it may be continuous with the periosteo-

capsular layers already separated upon the outer side. The internal lateral ligament is divided vertically in the manner already described with regard to the outer ligament.

As soon as the tibia is sufficiently free, the malleolar end of it is made to project a little through the wound, and while the soft parts are well protected with retractors, the bone is divided horizontally with a key-hole saw. The fragment is grasped with lion forceps and removed.

6. *The Sawing of the Astragalus.*—The surgeon finally turns once more to the outer incision, and through that wound removes with the saw as much of the upper part of the astragalus as is necessary. The section should be horizontal. If thought necessary, the whole of the astragalus may be removed through the external incision.

Comment.—The operation just described follows the subperiosteal method, and in all suitable cases that form of excision should be observed so far as is possible.

The ankle is peculiarly well adapted for the employment of the subperiosteal method, and the excellence of the results obtained in some reported cases has been ascribed to the sparing of the periosteum and the ligaments. Sir Wm. MacCormac observes that "no form of subperiosteal excision can be performed more thoroughly than that at the ankle."

The lateral incisions may vary considerably from those described in the text.

The outer incision may follow the posterior border of the fibula, and be made to bend suddenly forwards beneath the malleolus, when the tip of that process is reached. This was the outer incision of Moreau. Or a vertical cut so placed may be met by a transverse line, which extends as far forwards as the tendon of the peroneus tertius.

The inner incision has been made to form a **U**-shaped flap corresponding in width to the shaft of the tibia, or has assumed something of the outline of an anchor, a vertical cut being joined by a transverse incision at its upper end and a curved one at its lower.

The operation by means of a transverse incision across the front of the ankle-joint may be absolutely condemned. It is not adapted for the subperiosteal method, many tendons

must be cut, synovial sheaths are opened up, and the anterior tibial artery may need to be secured.

The removal of the entire astragalus is insisted upon by many who advocate the operation in cases of bone disease.

Farabeuf saws through the tibia and fibula together, using a key-hole saw, and protecting the soft parts with retractors.

Some operators take no trouble to save the peronei tendons from division.

Most essential is it that every care should be taken of the sheaths of the tendons.

Some surgeons, after the removal of the fibula, saw off the upper part of the astragalus, then make the inner incision, and finally remove the tibial segment.

After-treatment.—The after-treatment is a matter of extreme importance, and may have a greater influence upon the success of the measure than the actual operation itself. The foot and leg must be fixed in a suitable splint, the line of the new joint being rectangular. A plaster-of-Paris dressing, with windows to permit of drainage and the inspection of the wound, is recommended by many; or in the place of it a special splint of light wire may be employed. It is desirable that the limb, when fixed in the apparatus selected, should be suspended from a suitable cradle. The gap left by the removal of the bones should be maintained by extension.

Great care must be taken to keep the foot in a straight line with the leg, as a lateral deviation of the limb is very easily produced if this point be not strictly attended to. "If motion be sought for, passive movements ought to be commenced very early; but sound anchylosis is the most common and most desirable result.

"It is afterwards necessary to wear an instrument with lateral cross supports for a considerable time, in order to prevent any giving way of the new joint. A support behind, in the form of an artificial gastrocnemius, is often useful; this is effected by means of a rubber cord attached to the heel of the shoe and to a strap at the knee. The os calcis is prevented from slipping forwards by this means" (MacCormac).

Results.—The older statistics (as represented by those

The incision, in dealing with the tibia, should be vertical, and be parallel to, and just in front of, the internal border of the bone. When the part to be removed has been bared, the bone may be severed with a chain-saw or a chisel.

In cases in which the tibia is sound, removal of very considerable portions of the fibula may be undertaken without any marked deformity of the limb resulting. It is well that the upper and lower ends should be preserved whenever possible.

In removing the head of the fibula, it is possible to effect an opening into the knee-joint, or to do damage to the anterior tibial and musculo-cutaneous nerves.

If the malleolus be excised, the foot is apt to become everted.

In dealing with the upper half of the fibula the incision should be carried along the posterior part of the bone so as to fall behind the peroneal muscles.

In dealing with the lower half it may follow a continuation of the long axis of the outer malleolus, and be placed therefore in front of the muscles.

CHAPTER XVIII.

EXCISION OF THE KNEE.

THIS extensive and serious operation has been performed for numerous conditions, but is now mainly limited to the treatment of certain forms of chronic joint disease.

In acute disease it has been comparatively unsuccessful, and in the present position of surgery may be regarded as almost unjustifiable.

It is but very rarely demanded in examples of complicated and compound fracture and dislocation.

The results that have attended the operation when performed for gunshot injuries have been such that the measure is considered by most surgeons to be contra-indicated in these cases.

As a means of treating anchylosis in a deformed position, excision has been almost entirely replaced by osteotomy.

The value of the operation has been the subject of long-continued, elaborate, and voluminous discussion, and the position of the procedure has been substantially modified by improved methods of treating joint affections, by improved means of dealing with wounds, and by the introduction of the operation known as arthrectomy.

Excision of the knee was first deliberately performed by Park in 1781. The patient was the subject of chronic disease of the joint, and an excellent result followed. A less definite operation had been previously carried out by Felkin, of Norwich, in 1762.

For many years subsequent to that date excision of the knee was but very rarely performed, and the operation was regarded most unfavourably. The measure was, however, revived by Fergusson in 1850, and during the twenty or thirty years after this time the operation was taken up by English, French, German, and American surgeons, with

a remarkable enthusiasm, and the recorded cases published during the period named may be counted by hundreds. Of late years a reaction has taken place, and excision of the knee has now a place among operations which are but rarely performed, or which are extensively practised but by very few.

At the present time excision of the knee is but rarely carried out in private practice, and in hospital wards the procedure would appear to be becoming rarer and rarer.

The result aimed at is the production of a rigid anchylosis in the extended position, and the attempts to obtain a mobile joint have met with very few successes and a very numerous list of lamentable failures.

The subperiosteal method can hardly be carried out in this articulation, and may be considered as inapplicable.

The after-treatment is, on the whole, of more importance than the operation itself. Displacement of the bones—and notably a gliding of the femur forwards—is very apt to occur.

In young subjects great care must be taken not to encroach upon the lower epiphysis of the femur, which is the most important epiphysis of the lower extremity.

An admirable criticism of the operation is provided by Mr. Howard Marsh in his manual on "Diseases of the Joints."

Anatomical Points.—This articulation is the largest in the body, and owes its great strength to the powerful ligaments which unite the two component bones, and to the muscles and fasciæ that surround it. It derives no strength from the shape of the articular surfaces, since they are merely placed in contact with one another.

The axis of the limb is abruptly altered at the knee-joint, the femur inclining inwards from the pelvis, and the tibia being vertical.

The lateral ligaments of the joint are comparatively feeble, the posterior ligament is substantial, and the anterior part of the capsule is formed of a firm aponeurotic expansion. The most powerful and most important ligaments of the joint are the crucial.

The synovial membrane of the knee-joint extends upwards as a large cul-de-sac above the patella and beneath the extensor tendon (Fig. 203). This cul-de-sac reaches a point an inch or more above the upper margin of the trochlear surface

of the femur, and is rendered very distinct when the joint is distended with fluid (Fig. 203).

Above the synovial pouch is a bursa which separates the quadriceps tendon from the femur and is usually over an inch in its vertical measurement.

Fig. 203.—VERTICAL SECTION OF KNEE-JOINT DISTENDED WITH FLUID. (*Braune.*)

a, Vastus externus; *b*, Crureus; *c*, Short head, and *d*, Long head of biceps; *e*, Plantaris; *f*, Gastrocnemius; *g*, Popliteus; *h*, Soleus; *i*, Tibialis posticus; *j*, Bursa patellæ; *k*, Ligamentum patellæ; *l*, Ligamentum mucosum; *m*, Anterior crucial ligament; *n*, External semilunar cartilage; 1, External popliteal nerve; 2, Popliteal artery.

This bursa communicates with the synovial cavity in about eight cases out of ten.

The upper third of the patellar ligament is in relation with the synovial membrane, from which, however, it is separated by a pad of fat; the lower two-thirds of the ligament are in relation with the bursa between the ligament and the tubercle of the tibia.

A knife passed horizontally backwards at the apex of the patella would, when the healthy limb is extended, just miss the joint-line between the femur and tibia, and would hit the latter bone. If, however, there be any effusion in the joint, or the limb be a little flexed, a knife so introduced would pass between the two bones (Fig. 203).

The irregularity of the synovial cavity lends itself to the collection of masses of diseased tissue within the joint.

In the popliteal space the large bursa which is interposed between the internal condyle of the femur, the inner head of the gastrocnemius, and the semi-membranosus, usually communicates with the knee-joint.

The bursa beneath the popliteus tendon usually opens into the superior tibio-fibular joint on the one hand, and

always leads into the knee-joint on the other. It serves therefore to establish a communication between these two articulations.

The upper limit of the femoral epiphysis will be represented by a horizontal line drawn across the bone at the level of the tubercle for the adductor magnus. If the whole of the trochlear surface be removed in the excision, the whole of the epiphysis will have been taken away (Fig. 204). A single nucleus appears in this epiphysis shortly before birth, and joins the shaft about the twentieth year. The epiphyseal line is intracapsular.

The limits of the tibial epiphysis are represented behind and at the sides by a horizontal line that just marks off the tuberosities. It includes, therefore, the depression for the insertion of the semi-membranosus, and also the facet for the fibula.

In front the epiphyseal line slopes downwards on either side to a point on the upper end of the shin, so as to enclose the whole of the tubercle of the tibia.


Fig. 204. —EPIPHYSES OF THE FEMUR, TIBIA, AND FIBULA.

The centre joins the main bone at the twenty-first or twenty-second year. The epiphyseal line is extra-articular. Farabeuf estimates that in a child of about eight years of age it is impossible to remove more than 1 c.m. of the tibia, or $1\frac{1}{2}$ c.m. ($\frac{7}{12}$ of an inch) of the femur, without approaching dangerously to the epiphyseal lines.

After puberty (*e.g.*, in a youth of seventeen years) it is possible to remove $1\frac{1}{2}$ c.m. of the tibia, and $2\frac{1}{2}$ c.m. (1 inch) of the femur, without compromising the epiphyseal lines.

The popliteal artery is so placed that it is in greater risk

of being wounded when the tibia is sawn than when the lower part of the femur is being removed.

1. **Operation by a Curved Transverse Anterior Incision.** Of the many methods that have been described and adopted, this appears to have substantial claims to be regarded as the most suitable.

The particular incision employed is accredited to Textor, and a very similar incision was used by Sanson and Bégin.

Position.—The patient lies upon the back, with the limb close to the margin of the table. The lower part of the leg should project a little beyond the table, so that when the knee is bent at a right angle the foot may be able to rest, flat upon the sole, upon the end of the table.

Fig. 205.—EXCISION OF THE KNEE.
A, Transverse curved incision; B, Park's incision.

The surgeon stands upon the side to be operated on.

Some surgeons prefer to stand upon the left side of the limb in the case of either extremity, a position which is certainly more convenient for sawing.

One assistant places himself opposite to the surgeon, and steadies the limb by the thigh. Another assistant near the foot of the table holds the leg, and manipulates it as required. A third assistant by the surgeon's side attends to the sponging, etc.

At the commencement of the operation the limb is held with the knee a little flexed. Later, the joint is bent at a right angle.

1. *The Skin Incision.*—A curved incision, convex downwards, is made across the front of the knee below the patella.

The incision commences and terminates at the posterior margin of one of the femoral condyles, while its lowest point in front corresponds with the insertion of the patellar ligament (Fig. 205, A).

During the making of this wound the knee-joint is held

a little flexed, and the skin and subcutaneous tissues are alone divided at the first sweep of the knife.

2. *The Dividing of the Ligaments.*—The knee is now flexed a little more, and with another sweep of the knife

Fig. 206.—EXCISION OF THE KNEE: THE SAWING OF THE LOWER END OF THE FEMUR. (*After Farabeuf.*)

The soft parts are retracted by a band of india-rubber or a loop of thin metal.

the anterior part of the capsule and the patellar ligament are cut through, and the joint opened below the knee-cap.

The patella, with its attached aponeurosis, is turned upwards, the joint is still more flexed, and the surgeon proceeds to divide in order the lateral and the two crucial ligaments.

3. *The Sawing of the Femur.*—The joint is now bent at a right angle, and the limb held firmly in that position, with the sole of the foot planted upon the table.

The femur is cleared with the knife at the future saw-line.

The bone is sawn from before backwards, and with regard to the plane of the section these two points must be observed:—

The plane of the saw-cut in the antero-posterior direction must be at right angles to the long axis of the shaft of the femur, and in the transverse direction it must be parallel to the plane of the free surface of the condyles.

During the sawing process the condyles may be grasped and steadied with lion forceps, although, if the limb be firmly held, this is not necessary. The femur rests upon the tibia. The tissues of the ham must be protected by means of an ivory spatula held behind the femoral condyles, or by a broad elastic or thin metal band, as shown in Fig. 206.

4. *The Sawing of the Tibia.*—The upper end of the tibia is now held forwards, the foot is still pressed firmly against the table, the shaft of the bone is maintained in the vertical position, and in consequence the articular surface will be quite horizontal. The bone is cleared with the knife for the passage of the saw, and a thin slice is removed by sawing from before backwards, the saw being kept precisely parallel to the articular surface, and therefore at right angles to the shaft (Fig. 207). The popliteal tissues must be protected in the manner already described; and if the movements of the saw be slow and deliberate, there is no danger of wounding the structures of the ham.

The two bony surfaces should now be parallel, and should fit accurately when brought together.

5. *The Treatment of the Patella and Synovial Membrane.*—The most tedious part of the operation remains. The patella must be dealt with according to the practice of the individual surgeon. It may be removed, whether healthy or diseased, by dissecting it out, with the least possible disturbance of the surrounding tissues; or if entirely sound, it may be left. Or it may be steadied in a vertical position while its articular segment is removed with the saw in the form of a thin layer; or its tissue may be so scraped and cut away that nothing remains but the anterior layer of compact bone.

With the knife and scissors, aided by the sharp spoon, the surgeon now proceeds to remove all the diseased synovial membrane which may remain. The pouch beneath the quadriceps tendon is opened up, and is carefully cleared out by means of the sharp spoon.

Any existing sinuses are opened up and scraped, and by one means or another a careful and determined attempt is made to rid the operation area of every trace of diseased tissue. The part is now well washed with a carbolic solution—1 in 40—and carefully dried.

Nothing remains but to close the wound with sutures—silkworm gut being the best for the purpose—and to adjust the limb upon the splint which has been prepared for it.

The question of uniting the bony surfaces by means of wires or ivory pegs is considered afterwards (page 689).

A drainage-tube is introduced into the posterior angle of the wound on either side; or a single tube may be passed behind the bones, and be made to traverse the depths of the wound from one side to the other.

Fig. 207.—EXCISION OF THE KNEE: THE SAWING OF THE TIBIA.

The sutures should not be introduced until after the limb has been fixed upon the splint, so that up to the last moment the surgeon may be able to satisfy himself that the bones are in proper position.

The drainage-tubes will be inserted before the limb is adjusted to the apparatus.

No blood-vessels of any importance are divided. The arteries actually severed will be branches of the articular arteries, of the anastomotica magna, and of the anterior tibial recurrent. Continued pressure with a dry sponge will be sufficient to check such bleeding as is usually met with.

Comment.—Neither a tourniquet nor Esmarch's elastic band is required in this operation.

The knife used should be rounded at the point.

In the majority of instances it is possible to leave the posterior ligament undisturbed, in which case a substantial barrier remains that will prevent the spread of suppuration into the popliteal space should pus be produced.

In any case, care should be taken to spare this ligament, and to separate its attachments from the bones rather than to cut it.

With regard to the patella, no great good can result from

its retention. If partly diseased, and the morbid parts be removed, there is still a fear of the mischief reappearing and extending. If apparently sound at the time of the operation, it may, if left, become attacked by destructive inflammation during the healing process.

The retention of the bone and of the patellar ligament does not assist in retaining the femur and tibia in position, inasmuch as the ligament becomes loose and relaxed when the limb is adjusted upon the splint.

Since firm anchylosis is aimed at after the operation, the quadriceps muscle is of little value, and it has not been shown that the retention of the patella has increased the usefulness of the limb.

It is better, therefore, to remove the bone in any case, and in effecting its excision it should be carefully dissected out, and all the fibrous tissue around it be preserved, provided such tissue be free from disease.

The internal limit of the incision should not be carried backwards beyond the point indicated, in case the internal saphenous vein and nerve be wounded.

The utmost care must be taken to respect the epiphysis in young subjects. If damaged, it will lead to a shortened, deformed, and possibly useless limb.

The femur and tibia should be sawn from before backwards. The best instrument is a wide-bladed thin saw with a movable back. In the hands of some surgeons a Butcher's saw appears to be more convenient. There is no real danger of wounding the popliteal vessels in sawing the tibia if reasonable care be exercised, and there is consequently no need to adopt the somewhat difficult manœuvre of sawing that bone from behind forwards.

The precise manner in which the femur is sawn is of primary importance. If the section be not made as directed, the bones may not come well together, a subsequent displacement would be encouraged, while the best conditions are not provided for securing firm anchylosis. On the other hand, the limb may assume the deformed position of either knock-knee or bow-knee.

In adjusting the bones the two surfaces should be made to come accurately and evenly together, and in bringing them

into position care must be taken not to pinch the relaxed posterior ligament between the hinder margins of the freshly-cut femur and tibia.

The limb should be so disposed as to be absolutely straight, and the position of slight flexion advised by some is distinctly to be condemned.

In the final scraping away of the diseased soft parts, especial care must be taken to fully expose and evacuate the supra-patellar synovial pouch.

With regard to the fixing of the bones with metallic sutures or pegs, it must be observed that such a measure effects its object but feebly, that primary healing is apt to be hindered, that the subsequent removal of the wires or pegs may be difficult, and that the presence of these foreign bodies may excite some carious mischief in the bones.

If a really suitable, strong, and well-adjusted apparatus be used to fix the limb, the employment of the means just named becomes quite unnecessary.

The introduction of the use of metallic sutures in this operation is ascribed to Dr. Buck, of New York.

The use of pegs is, however, advised by some eminent and practical surgeons, and notably by Mr. Howard Marsh. He comments upon this measure in the following words ("Diseases of Joints," page 330):—

"A method which greatly assists in keeping the fragments in apposition, and therefore still further enables the surgeon to dispense with circular constriction of the thigh, is that of pegging the bones together, introduced by Mr. Baker, of St. Bartholomew's Hospital. Mr. Baker employs two steel pins about the size of knitting-needles. These are passed, one on the inner and the other on the outer side of the limb, through the skin into the tibia, and on for about an inch and a half into the femur. They are removed (an easy matter, as their ends are left projecting) on the tenth to the twelfth day. Mr. Willett prefers bone pegs, which are cut off short and allowed to remain. I have used these bone pegs in six cases. They certainly fix the ends of the bones in a very satisfactory manner. I have allowed the ends to project, and have left them in place for a month, till all chance of movement between the bones has passed by.

"In some instances I have found the pegs by this time so firmly held that I could not withdraw them, and I have therefore, cut them short and left them; others have been loose, and have been easily removed."

With regard to the general circumstances of the operation, Mr. Jacobson ("The Operations of Surgery," page 1013) writes. "Before and throughout an excision of the knee, the operator should bear in mind the following points:—(1) To remove every atom of the disease; (2) to secure good drainage; (3) to leave the bones in good position; (4) to ensure absolute immobility afterwards; (5) to watch for and at once attack any relapse. . . . Before the time of the excision, any flexion of the knee should be corrected, as far as possible, by careful weight extension. A knee should never be excised while flexed. Such a step will not only be liable to lead to removing bone needlessly in order to straighten it, but stretching the contracted deep fascia and nerves may lead to tetanus. The risk of gangrene has also been already mentioned."

2. **Other Methods of Excising the Knee.**

The many operations, with which the names of as many surgeons are associated, differ but little from one another except in the matter of the skin incision.

A. Park employed a species of crucial incision (Fig. 205, B), which has met with few imitators.

B. An anterior U-shaped flap was introduced by Mackenzie, and has been extensively adopted by English and other surgeons. The smaller of the so-called flaps is but a slight modification of the transverse curved incision above described. The larger form of flap had its base on a level with the upper limits of the femoral condyles, and its apex or free end opposite the tubercle of the tibia (Fig. 208, A).

This flap is unnecessarily large, and involves a very extensive wound.

C. Moreau employed an H-shaped incision, which was accepted by many of the earlier operators with certain more or less insignificant modifications.

One form of incision employed by Ollier reverts to this early method of dividing the skin (Fig. 208, B). Ollier attempts to carry out the excision as far as possible upon the subperiosteal plan; but the anatomy of the joint, and the conditions

under which the operation is usually performed, do not lend themselves to this method, which is, indeed, distinctly unsuited to this part of the body. Even if carried out precisely upon the lines laid down by Ollier, it is still incomplete. An extensive arthrectomy is the nearest approach to a subperiosteal operation.

D. Longitudinal incisions are employed by some surgeons. The incision may be median, and the patella either turned aside or split vertically, and then united by suture after the operation is completed.

Langenbeck employs a vertical cut some five inches in length, which is situated upon the antero-internal aspect of the joint. The knife divides the vastus internus half-way between the inner edge of the patella and the internal condyle, and is arrested opposite to the inner tuberosity of the tibia.

The bones are dislocated inwards, and removed.

Jeffray, Sédillot, and William Knight Treves employed two vertical lateral incisions, dividing the bones by means of a chain-saw or a very narrow hand-saw.

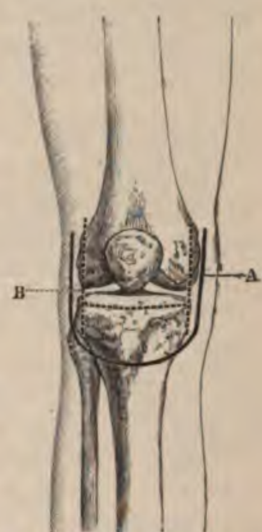

Fig. 208.—EXCISION OF THE KNEE.
A, U-shaped flap; B, Ollier's subperiosteal method.

These operations by means of longitudinal incisions were for the most part designed with the purpose of saving the patella and its ligament, and were founded upon the belief that the preservation of those structures was of primary importance in the future utility of the limb.

The method by a longitudinal incision is difficult and tedious, a small space is provided, a good view of the interior of the joint cannot be obtained, the removal of all the diseased tissue is less surely effected, and good drainage cannot be provided for unless a special drainage incision be made.

E. Golding Bird preserved the patella, but sawed it

through transversely to reach the joint, and after the excision united the two fragments of the bone together with sutures. Dr. Fenwick, of Montreal, saws both femur and tibia in a curved line, "so as to make them fit together more closely and accurately than they would do otherwise."

There is nothing to recommend this operation, while many very cogent arguments may be urged against it.

After-treatment.—The after-treatment is of the utmost importance, is tedious, and often surrounded with difficulties. There is a tendency to displacement, and notably to a displacement of the tibia backwards. If sound healing do not take place, the limb is worse than useless, and the flail-like limb that may result is of less service to the patient than a good artificial leg.

The limb must be put up perfectly straight—*i.e.*, in the position of complete extension—and for the purpose of fixing it many surgeons employ plaster-of-Paris. The rigid dressing formed of this material is not entirely satisfactory. It may exercise an unequal pressure upon the parts, and may lead to œdema, etc. Discharge may find its way between the splint and the limb, the dressing is difficult to remove, and even when large "windows" are provided the inspection of the part can never be so complete as it should be.

Such a splint should be provided as will allow the bones to be kept in good position, will permit of a free inspection and examination of the wound, and will not interfere with dressing and drainage.

It is well that the splint should be suspended.

Mr. Howard Marsh points out that "the plan of firmly bandaging the lower end of the femur to the back splint leads to great swelling about the wound, and materially retards repair. It is apt, also, to induce persistent venous oozing after the operation." To avoid these drawbacks, he employs Gant's splint. This simple splint, instead of binding the femur down to the level of the tibia, brings the tibia up to the level of the femur, and no tight bandaging is called for.

Another splint which answers admirably in the after-treatment of excision of the knee is Howse's splint (described in *Guy's Hospital Report*, 1877, page 503).

Not a few of the splints employed have the disadvantage of being complex, and difficult to adjust.

Dry dressings should be applied to the wound.

The limb must be kept upon the splint until it is sound. This period will vary from six weeks to three months. Complete recovery can usually not be expected until six months have elapsed.

After the splint has been removed, a light leather support, strengthened with a strip of steel at the back, should be applied; and in the case of children Mr. Jacobson advises that such a support should be worn for three or more years.

A thick-soled boot will be required to meet the inevitable shortening.

Results.—The results in very young children (under five years of age) have been bad, and the same may be said of patients over thirty. Excision of the knee in adults over forty has been attended with very bad results.

The mortality of excision for disease is about 20 to 25 per cent.; of excision for injury, about 40 per cent.; and of excision for gunshot wounds, about 80 per cent.

The best result is obtained when firm anchylosis follows. Deformed, stunted, and flail-like limbs are common after this operation; and when the excision has been performed for tubercular disease, a relapse is, unfortunately, not uncommon.

EXCISION OF THE FEMUR.

Excisions of portions of the femur, apart from the removal of large sequestra, are very rarely indeed carried out.

In the treatment of gunshot injuries it would appear that these operations are attended by a mortality of nearly 70 per cent. (Otis). In acute bone disease the indications for an excision operation are seldom clear, and better methods of dealing with ununited fracture of the shaft have been devised.

To reach the shaft of the bone the incision should be made upon the outer side of the limb, and be carried down to the bone between the vastus externus and the short head of the biceps muscle.

CHAPTER XIX.

Excision of the Hip.

This operation usually implies the removal merely of the upper end of the femur, and the scraping away of any diseased tissue which may occupy the acetabulum. As in the case of the shoulder-joint, so here also the excision does not involve the whole joint and the entire articulating surfaces.

The value of the operation, the conditions under which it should be performed, and the character of the results obtained, have been, and still are, subjects upon which the most diverse opinions are held.

It may be assumed, in the first place, that excision of the hip is usually performed for chronic suppurative joint disease occurring in young subjects. In all but a quite small proportion of the cases the mischief is tubercular.

The age between six and fourteen is considered to be the best for the operation, and few even of those who practise excision extensively would carry out this measure in patients over sixteen years of age. One or two surgeons have expressed the opinion that the operation should never be performed in patients under the age of ten.

Mr. Howard Marsh is very adverse to the operation ("Diseases of the Joints," 1886). He considers that the treatment by continued rest provides such admirable results (recovery with but slight lameness and but slight loss of movement in 70 per cent. of the cases, and a mortality of about 5 per cent.) that the conditions which would sanction excision are exceedingly few. Even when suppuration has occurred, he would not place the mortality above 6 or 8 per cent.

He considers that operation in the early stage of the disease is unjustifiable, and that in very advanced disease the excision will be of doubtful benefit.

Mr. Wright, on the other hand, is strongly in favour of the

operation, and considers that it should be performed early—at least, as soon as there is any evidence of external abscess ("Hip Disease in Childhood"). Mr. Wright has performed excision in over one hundred cases, while at the London Hospital only four excisions of the hip have been performed in four years.

Mr. Barker, in his "Hunterian Lectures" (1888), advocates with some reserve excision in the early stages of the disease, and considers that the cases of advanced mischief in the joint are unsuitable for excision. The method of operating advised by Mr. Barker (page 703) has been attended with considerable success.

The usefulness of the limb obtained after excision has also been the subject of considerable difference of opinion.

Into this very wide, complicated, and vexed question it is impossible here to enter. It is only necessary to point out that the position of this operation cannot yet be considered to be fully established, and it may be suggested that the truth will be found to be in a course midway between the two very adverse modes of practice to which allusion has just been made.

Excision of the hip for gunshot injury has been attended with a terrible mortality. Otis's statistics show a death rate of 90·9 per cent. The same statistics, however, show that in the cases treated by conservation the mortality was 98·8 per cent., and in those treated by amputation it was 83·3 per cent.

The excisions at one time practised for anchylosis in a bad position have been replaced by osteotomy.

Excision of the hip was first suggested by Charles White, of Manchester, in 1709. It was first performed by Anthony White, of the Westminster Hospital, in 1818. The operation was carried out on a boy of 14 to remedy the result of long-standing hip disease. Four inches of the femur were removed. A good recovery followed.

The operation was but seldom practised until the time of Sir William Fergusson, who did much to bring the measure into general use (*Med.-Chir. Trans.*, 1845).

Within recent times the operation has perhaps been somewhat too extensively and too indiscriminately practised; and after a reaction in the opposite direction of condemning the

operation altogether has passed away, the true use and position of the excision will no doubt be established.

Anatomical Points.—The hip-joint is deeply placed, and is surrounded by numerous muscles. In front are the psoas and iliacus; behind, the quadratus femoris, the obturator internus, the two gemelli, and the pyriformis; on the outer side are the gluteus medius and minimus and the rectus; and on the inner side are the pectineus and obturator externus.

The capsule of the joint is exceedingly strong, and forms indeed the strongest ligament in the body.

The thickest parts of the capsule have received the names of the ilio-femoral, the ischio-femoral, and the pubo-femoral ligaments. The capsule is thinnest between the ilio-femoral and pubo-femoral ligaments, and here the synovial sac often communicates with the bursa which lies beneath the psoas muscle at this spot. The capsule is also weak where covered by the obturator muscles.

The upper border of the great trochanter is on a level with the centre of the hip-joint. A line (Nélaton's line) drawn from the anterior superior iliac spine to the most prominent part of the tuber ischii will cross the centre of the acetabulum and will hit the top of the great trochanter.

The head of the femur lies close below Poupart's ligament, and just to the outer side of its central point.

The position of the chief bursæ about the hip-joint should be borne in mind.

Ossification commences in the head of the femur ten months after birth, in the great trochanter in the fourth year, and in the lesser trochanter in the thirteenth year. The last-named process of bone joins the shaft at the age of eighteen, the great trochanter joins about eighteen and a half, and the head about the nineteenth year. The neck is ossified by an extension from the diaphysis, and this upper extremity of the shaft serves to separate the head from the two trochanters.

The acetabular element of the os innominatum ossifies in the sixth year from one or more centres which appear in the **Y**-shaped cartilage.

The bone so produced joins with the ilium and the ischium at the age of fourteen, and with the os pubis at

fifteen. The ossification of the acetabulum is completed at about the age of seventeen years.

The shortening which follows upon removal of the upper end of the femur in a young subject is much less than would be expected. Indeed, such diminution of length as follows would appear to be due rather to the actual loss of bone, to some possible displacement of the upper end of the femur, and to the general atrophy, which is marked in the entire extremity. The principal increase in the femur is effected by the lower epiphysis. Little growth is accomplished by the upper. A main feature in the shortened limb after hip disease is certainly due to a general arrest of development in the entire limb.

THE OPERATION.

The following methods, most usually employed at the present day, will be described with such comments as bear upon their comparative advantages and disadvantages :—

1. By an external incision (Langenbeck's operation).
2. By the subperiosteal method.
3. By an anterior incision (Lücke's operation and Barker's operation).
4. By a posterior incision.

1. By an External Incision (Langenbeck's Operation).

The patient lies upon the sound side, with the thigh flexed at an angle of 45 degrees, and rotated a little inwards.

The surgeon stands to the outer side of the limb. An assistant at the foot of the table holds the leg, and manipulates the extremity as required. A second assistant stands on the opposite side of the table facing the surgeon, and attends to the sponging, etc. A third assistant may take his place close to the patient's trunk and by the operator's side. He can assist with the retractors.

(1) *The Incision.*—A straight incision about four or four and a half inches in length is made in the long axis of the limb, and over the outer surface of the great trochanter. It falls a little behind the middle of that process, and in the position in which the limb is placed would fall upon a line directed downwards from the posterior superior iliac spine to follow the long axis of the femur. Two-thirds of the incision

will lie over the ilium, and one-third over the great trochanter and femur.

The upper extremity of the wound will be about opposite to the superior margin of the great sciatic notch (Fig. 209).

(2) *The Opening of the Joint.*—The knife is carried directly down to the bone and the capsule of the hip-joint.

The knife therefore divides the glutei muscles in the direction approximately of their fibres. The wound may be enlarged if needed. The capsule is opened in the line of the skin incision. It is also divided transversely, close to the acetabulum, so that the section of the ligament is T-shaped.

Fig. 209.—EXCISION OF THE HIP: LANGENBECK'S EXTERNAL INCISION.

By cutting the cotyloid ligament air is admitted into the joint, and the femur becomes separated from the acetabulum. The condition of the bones can now be ascertained with the finger.

The muscles attached to the great trochanter are now divided close to their insertion into that bone. The limb is rotated inwards, in order to expose the connections of the posterior muscles, and rotated outwards to reach and divide the anterior muscles.

The ligamentum teres will probably have disappeared; if not, it must now be severed.

(3) *The Application of the Saw.*—The head of the bone is dislocated backwards, and thrust as far as convenient into the wound. While the soft parts are protected by means of retractors and spatulæ, the surgeon divides the upper end of the femur by means of a narrow saw.

Such arterial twigs as bleed can probably be secured by

means of pressure forceps, and the application of a ligature to any vessel will seldom be required.

The surgeon finally removes, with the gouge or chisel, any diseased bone which may be found in the acetabulum.

With the sharp spoon he then proceeds to scrape out the cavity of the joint, and to remove any traces of diseased synovial tissue which may be left. Sinuses are scraped and opened up. The joint is well washed out with a carbolic solution—1 in 40—and is then well dried with the sponge.

The sutures are inserted, and a drainage-tube introduced.

Comment.—No Esmarch's tourniquet is required in this or any other method of excising the hip.

If the head of the femur be dislocated upon the dorsum, the incision will have to be a little modified. It may be made small at first, and enlarged as required.

In young subjects the cartilaginous tissue, of which the great trochanter is still in part composed, may be peeled off with the muscles, the rugine being used instead of the knife.

During the sawing of the femur care should be taken to disturb the periosteum as little as possible.

The head of the bone may be steadied by means of the lion forceps while being sawn.

The actual amount of bone removed from the femur must depend mainly upon the extent of the disease. This, however, is not the sole consideration, and upon this point the opinion of Mr. Jacobson may be expressed:—"I think that the section through the great trochanter (*i.e.*, just below its upper margin) is preferable to one above it (*i.e.*, through the neck). This has the advantages of disturbing and damaging the attachments of muscles much less, and thus leads to more rapid healing and far greater mobility of the limb. These, however, are outweighed by the disadvantage which leaving such a large piece of bone as the trochanter entails—viz., that after healing, this process gets drawn up against the scar and constantly frets it. It is also said to check the escape of discharges, and to render the patient liable to persistence or recurrence of the disease. I am doubtful as to the last two, but the first is absolutely certain" ("The Operations of Surgery," page 973).

Mr. Barker is not disposed to admit the objections which

have been urged against the retention of the trochanter, and advises that under any circumstances as little bone should be taken away as possible, compatibly with thorough removal of the diseased portions.

This operation follows very emphatically the lines of the "open method," and is a little crude and a little regardless of the tissues in the vicinity of the joint.

It may claim to be easy and safe. The bone is well and readily exposed, and is very easily sawn.

Good drainage is allowed for.

The disadvantages of the method are the following:—Many large and important muscles are cut through, and the stability of the new joint possibly weakened thereby. The soft parts are exposed to much handling and some bruising. Many of the arteries which meet about the great trochanter are divided. A transverse section is made of the capsule, and the strength of that ligament is consequently weakened.

2. By the Subperiosteal Method.

(1) *The Incision, and the Exposure of the Neck of the Femur.*—The incision is precisely similar to that just described; and the positions of the patient, of the limb, and of the surgeon, are identical with those observed in the previous operation. The skin and subcutaneous fat are divided, and the part of the gluteus maximus muscle which is exposed is severed in the line of the skin incision, and the gap thus made in the muscles is widened by means of suitable retractors (Fig. 210). The surgeon now seeks with the finger for the gap between the gluteus medius (in front and above) and the pyriformis (behind and below). These two muscles are separated from one another, and in the gap between them and in the line of the original incision the knife is carried down to the great trochanter, the periosteum of which is divided (Fig. 210).

Now with one broad retractor the gluteus medius is drawn forwards and the pyriformis backwards, and the capsule, which is thereby exposed, is divided with the knife in the long axis of the femoral neck.

Passing through the capsule, the surgeon divides the periosteum of the neck in the same line, and continues this periosteal incision downwards over the upper margin of the

trochanter to join the incision already made in the membrane covering that process (Fig. 211).

The part is now ready for the rugine.

2. *The Anterior Capsulo-Periosteal Flap.*—With the rugine the surgeon now separates the periosteum from the

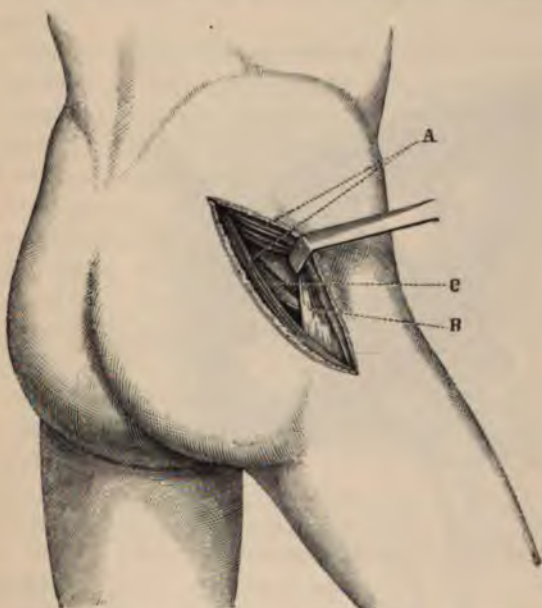

Fig. 210.—EXCISION OF THE HIP BY AN EXTERNAL INCISION.
A, Gluteus maximus; B, Gluteus medius at the great trochanter; C, Pyriformis.
(*After Farabeuf.*)

neck and the great trochanter, turning it forwards and backwards in the form of two flaps. To complete these triangular flaps the periosteum is divided transversely along the line at which the neck of the femur joins the articular cartilage of the head. The thigh is flexed and rotated outwards, and working the rugine from above downwards and from behind forwards, the inner part of the neck and of the trochanter are laid bare. In this stage of the operation the insertions of the gluteus medius and gluteus minimus, and of the Y-shaped ligament, are separated from the bone, together with the periosteum.

(3) *The Posterior Capsulo-Periosteal Flap.*—The thigh is now less flexed, is adducted and rotated inwards. The rugine is used from above downwards and from before backwards, and the periosteum is elevated from the outer part of the neck, from the digital fossa, and from the posterior part of the trochanter. With it is separated more of the capsule and the attachments of the obturators, the gemelli, and the pyriformis.

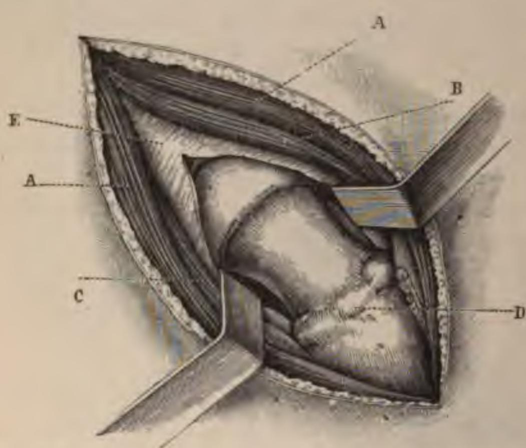

Fig. 211.—EXCISION OF THE HIP BY AN EXTERNAL INCISION.
A, Gluteus maximus; B, Gluteus medius; C, Pyriformis; D, Great trochanter; E, Capsule of hip-joint. (*Farabeuf.*)

4. *The Removal of the Upper End of the Femur.*—The head of the bone is dislocated backwards, and when free of the acetabulum the rugine is again used to clear all the remaining periosteum, with the remaining attachments of the capsule, from the neck of the femur. As this is being done, the periosteum along the line of its termination at the articular head is divided.

The thigh is flexed and adducted, and while the head is steadied with lion forceps and the soft parts are protected by spatulæ, the upper end of the bone is sawn through as far down as it has been laid bare.

Any disease of the acetabulum is dealt with in the usual way. A drain is introduced, and the sutures are inserted.

Comment.—This procedure is excellent in theory, but it can be of most limited application in practice.

Sir Wm. MacCormac is of opinion that the subperiosteal method may be carried out in children, and in cases of secondary resection after injury, but that it is impracticable

where excision is performed for recent injury in the adult. In the ordinary affection for which the operation is performed—viz., tubercular joint disease—it can seldom be desirable to preserve so much of the intracapsular periosteum. It has not been clearly shown that the preservation of this periosteum has had substantial effect upon the utility of the limb after the operation.

The procedure is difficult and tedious, and the deeper parts of the wound are so disposed as not to favour drainage. The method of dealing with the trochanter is, in suitable cases, worthy of adoption.

3. **By an Anterior Incision.**

Lücke's Operation.—The incision in this case consists of a straight line in the long axis of the femur, and from four to five inches in length. Commencing about half an inch below and to the inner side of the anterior superior iliac spine, it descends nearly vertically just to the outer side of the anterior crural nerve (Fig. 212).

Fig. 212.—EXCISION OF THE HIP: LÜCKE'S ANTERIOR INCISION.

The inner border of the sartorius is exposed, and then the rectus and the psoas.

The thigh is flexed, adducted, and rotated out, the sartorius and rectus are drawn to the outer side by suitable retractors, and the psoas to the inner side.

The capsule of the joint is thus exposed, and is incised vertically.

The cotyloid ligament is cut, the head of the bone freed and sufficiently displaced to allow of the saw being applied.

Barker's Operation.—This operation is described in the *British Medical Journal* (Jan. 19th, 1889). It has been attended with remarkably successful results.

The incision employed is that advised by Dr. Hueter in 1878, and independently by Mr. R. W. Parker (*Clin. Soc. Trans.*, vol. xiii.).

The patient lies supine, with both thighs fully extended.

The surgeon stands in every case on the right side of the patient; one assistant, facing him, holds the affected thigh, another stands beside and to the left of the operator.

The most precise and rigorous aseptic measures are carried out.

The incision commences on the front of the thigh, half an inch below the anterior superior spinous process of the ilium, and runs downwards and a little inwards for three inches. As the knife sinks into the limb it passes between the tensor vaginæ femoris and glutei muscles on the outside, and the sartorius and rectus on the inside, until it reaches the neck of the femur. This incision does not divide any muscle fibres, nor vessels or nerves of the slightest importance. It is unnecessary to carry the deeper part of the incision to the full extent of the external wound. If an abscess is opened up before the joint is reached, its contents are thoroughly flushed out with sterilised hot water, at a temperature of between 105° and 110°, before anything further is done. For this purpose a large three-gallon can is used, which has three taps below, to each of which six or eight feet of india-rubber tubing is attached. This can is placed some feet above the operating-table, so as to have a considerable pressure of water. Each of the rubber tubes terminates in one of Barker's flushing-gouges. These instruments consist of a gouge with a canal running through the handle, so that a stream of water may be directed into the hollow of the gouge. The abscess having been cleared out by means of the rush of hot water, aided by these flushing-gouges, the neck of the femur is sawn across with a narrow saw in the direction of the external wound. The diseased head can then be lifted out by means of the flushing-scoop or a sequestrum forceps, through which the hot stream is rushing into the joint. By the time the head of the bone has been got out, the whole cavity is comparatively clean. Now begins the search for further disease. This can usually be easily estimated by the left forefinger, with which the acetabulum is first examined, and then all the other parts of the joint-cavity. Wherever diseased material is felt, it is cut away by the flushing-gouge or scoop, the hot water carrying away the *débris* as fast as it is produced, and with it all blood, while at the same

time it arrests bleeding from the fresh-cut surfaces. When every part of the field of operation has been gouged and scraped clean of all tubercular material, and the water runs away clear, the cavity is dried out with carbolised sponges, one or two of which are left in it until all the stitches are placed in position. These, which are of hard carbolised silk, should dip deeply, and be placed close together. Just before they are tied, the sponges are removed, and with them the last traces of moisture. The wound is then filled up with iodoform emulsion, and the sutures are tied, as much of the emulsion being squeezed out at the last moment as will come away. A little iodoform is now dusted over the surface of the incision—in which there is no drainage-tube in most cases—and the whole joint is covered with salicylic wool, so adjusted in strips that evenly-graduated pressure is brought to bear upon every aspect of the field of operation, while the limb is held well abducted. If the wool be now firmly compressed with a spica bandage, the walls of the whole clean-scraped cavity are brought into contact, and the remainder of the neck of the femur is thrust into the acetabulum, and secured there.

Now when all this has been done, although there remains potentially a cavity, there is actually nothing of the kind, for all the surfaces have been brought into apposition. And then, assuming that perfect asepsis has been observed, all these surfaces ought to unite with a minimum of plastic exudation. After the operation the patient is at once placed upon a double Thomas's splint.

Comment.—Of these two procedures, the latter is undoubtedly the better. In Lücke's operation the incision is placed too far on the anterior surface, the capsule is not exposed through the most convenient inter-muscular space, the psoas muscle is not readily drawn aside, and the capsule must be opened through the ilio-femoral ligament. The external circumflex artery can scarcely escape division.

In speaking therefore of excision of the hip by an anterior incision it will be considered that Mr. Barker's operation is implied.

The advantages of this operation are as follows:—The capsule is reached by a short and direct route; no muscles are divided in exposing the joint; no vessels and no nerves of any

consequence are severed; the nutrition of the tissues around the joint can be but very little impaired; and the least possible amount of damage is inflicted upon the soft parts. The neck of the bone is divided *in situ*. The head is not wrenched out of the incision, a step which not only is apt to damage the surrounding tissues, but also to strip off the periosteum beyond the line of section. The position of the incision is very convenient in the after-treatment, and permits of an external or a posterior splint being applied without pressure being brought to bear upon the wound. The whole of the diseased tissue is removed. All these advantages are definite and substantial. One objection has been urged against the method. It is said that proper drainage cannot be carried out, and therefore healing must be delayed.

This objection Mr. Barker has fully met in his recent communications. He has found the anterior opening perfectly adequate for the drainage of the cavity left by the operation. Indeed, in the majority of the cases in which the whole of the tubercular disease has been removed no drainage-tube is employed, but the wound is at once closed. Out of seven cases reported (*Brit. Med. Journ.*, Nov. 1st, 1890), no less than six healed by first intention under one dressing. Mr. Bilton Pollard (*Med.-Chir. Trans.*, 1889) has reported four cases of excision in advanced hip disease with caseous abscesses. The operation was carried out upon the lines laid down by Mr. Barker. The anterior incision was adopted in three cases, the posterior in one. No drainage-tubes were employed. The wounds were dressed for the first time on the seventh day, and were found to have healed throughout by first intention.

So far as the reports of cases of excision of the hip afford material for comparison, it is clear that the operation above described has such advantages that it may claim to be considered the method of election.

4. By a Posterior Incision.

This operation differs but very little from the method by an external incision first described. The incision is retro-trochanteric, commences opposite to the highest point of the acetabulum, and is carried in a curved direction along the posterior part of the trochanter, maintaining through-

out a distance of about one inch from the border of the bone.

The gluteal muscles are cut through, the capsule is divided, and the head of the bone is dislocated and sawn off precisely as in the operation first described.

The method admits of excellent drainage, but it possesses the disadvantages which have been mentioned in connection with the external incision, the section of muscular tissue is considerable, and the wound is exposed to pressure during the after-treatment.

Other Methods of Operating.—The many methods which have been devised for the carrying out of this operation differ mainly in the situation of the incision.

Farabeuf gives illustrations of eighteen different methods.

Retro-trochanteric incisions are common. An incision advised by many is that known as the superior incision. It follows the neck of the femur above the trochanter, and then, if an extension of its length be needed, is carried along the posterior margin of that process. The T-shaped and the horseshoe-shaped incisions of the earlier operators have not survived the test of time, and the same may be said of the excisions carried out through flaps of various sizes and shapes, which were placed, for the most part, over the great trochanter. Such flaps were executed by Lisfranc, Sédillot, Percy, Roux, and others, but they involved a quite unnecessary amount of injury to the soft parts.

After-treatment.—Dry dressings should be employed, and if primary healing is aimed at, a fair degree of pressure should be brought to bear upon the part. A dressing of sponges dusted with iodoform, and secured in position by a firm bandage over a layer of cotton-wool, may be recommended. A useful method of dressing is described in the account of Barker's operation (page 705).

The limb must be kept at perfect rest, and in the position of extension. The sawn end of the femur should not be allowed to remain in actual contact with the acetabulum.

Of the many splints advised, the most convenient are either a double Thomas's splint, or a so-called box-splint. These splints are especially suited for cases in which the anterior incision has been made.

The child is held firmly, and can be lifted up and turned over without any movement being produced at the hip-joint. These cases require much care in the nursing. The average period involved in the after-treatment will probably be not much less than six months in any case in which the disease was advanced at the time of the operation.

Results.—The mortality after excision of the hip was, before the days of antiseptics, very high. Culbertson gives the mortality after operations for disease as 45·1 per cent. The mortality of the operation at the present day is, in properly selected cases, no higher probably than 5 per cent. Mr. Wright has given a list of over one hundred cases of excision, with only three deaths that may be ascribed to the actual operation.

The functional result after a successful excision is usually satisfactory. Anchylosis very seldom follows. The limb is frequently atrophied, and some shortening is inevitable. Sir William MacCormac estimates that about half of the successful cases can walk without the assistance of a stick, while the other half require one.

A flail-like condition of the limb, with, perhaps, a marked degree of shortening, will depend either upon the removal of an exceptionally large amount of bone, or upon allowing the patient to move the limb and bear weight upon it too early.

It must be acknowledged that, taking a large number of average cases, the results which follow the treatment by rest are superior in all respects to such as follow the treatment by excision.

CHAPTER XX.

Arthrectomy or Erasion of a Joint.

This operation, although it is distinct from excision, may most conveniently be considered here.

It consists in fully exposing the interior of the joint, and in removing the whole of the diseased synovial membrane and ligamentous tissue, together with such patches of cartilage or bone as may be the seat of quite limited disease.

This removal is accomplished by means of the scalpel, the scissors, the sharp spoon, the gouge, and, if need be, the actual cautery. The measure aims at removing *all* the diseased tissue, and diseased tissue *only*.

In principle it represents the application to the interior of the joint of a method of dealing with certain morbid conditions, known as the method by scraping, which has been developed within the last few years, and which the introduction of antiseptic measures has allowed to be applied to extensive and important districts.

The method is in reality a by no means modern procedure revived and improved. The operation of arthrectomy, as it is now known, would appear to have been of gradual and almost unconscious development. Surgeons began cautiously to apply to chronically-inflamed joints, and, perhaps, first of all to the sinuses about them, a method of treatment they had already found successful in like conditions elsewhere.

Mr. Herbert Page has given a brief account of the origin of excision of the knee and of arthrectomy (*Lancet*, Nov. 17, 1888).

It would appear that in 1881 Mr. Cross, of Bristol, advised the carrying out of the measure now known as arthrectomy, and he gave then an illustrative case.

Since that time the procedure has rapidly developed.

To Mr. G. A. Wright is due the credit of being among the

first to publish any detailed account of the procedure. He has, moreover, done much to elaborate and perfect the operation, to give it a definite position among surgical methods, and to establish its value and its application as a mode of treatment.

His first case was published in the *Lancet* for 1881. A fuller communication was made before the British Medical Association in 1883, and in 1885 a series of sixteen cases was published in the *Medical Chronicle.*

The operation is chiefly, if not entirely, applicable to the knee-joint. It has been carried out in the elbow and ankle, but, as Mr. Wright observes (*Lancet*, 1888), "in joints with complex bony surfaces, and in joints where free mobility is an important element, also in joints where the primary and main lesion is bony, the operation can never have any great measure of success."

Brüns' method of performing arthrectomy of the ankle is described at the end of this chapter.

Arthrectomy forms an essential part of all excisions for chronic joint-disease, it being necessary that all traces of tubercular tissue should be removed by scraping or dissection after the articular parts of the bones have been sawn off.

The measure may be regarded as a conservative one, and is applicable to relatively early cases. It is distinctly unsuited for examples of advanced disease, except as an accessory measure. It is not adapted for cases attended by much suppuration. It is especially applicable to children.

Instruments Required.—Excision knife; scalpels; scissors, both straight and curved on the flat; sharp spoons of various sizes and shapes; gouges; toothed forceps; dissecting and artery forceps; pressure forceps; probe; retractors.

The Operation (*as applied to the knee-joint*).—An Esmarch's band is not required, nor is any form of tourniquet needed.

The patient lies upon the back, with the knee a little flexed, and the sole of the foot resting flat upon the table.

The surgeon stands to the outer side of the limb, or he may find it convenient to place himself upon the right side in the case of either limb. An assistant placed at the end of the

table, and another opposite to the surgeon, hold the limb securely. A third helper by the surgeon's side attends to the sponging, etc.

A curved transverse incision is made across the front of the knee-joint, as in performing excision (page 684). The incision may be commenced at the posterior part of one condyle of the femur, be carried across the front of the limb over the middle of the patellar ligament, and end at the posterior part of the other condyle.

The patellar ligament is divided, the joint fully opened, and the skin flap with the patella turned up upon the thigh.

The knee is now flexed at a right angle, and the interior of the joint well exposed.

The surgeon then proceeds to remove all the diseased synovial membrane, and such of the extra-synovial tissue as is also involved. The latter would include all softened ligamentous tissue. As much as possible should be removed in a continuous layer by means of the scalpel and forceps, or the scissors and forceps. The semilunar cartilages are removed, and probably both lateral ligaments.

The crucial ligaments should be spared whenever possible. They must be stripped, however, of every trace of diseased membrane, must be most carefully inspected, and subjected to a vigorous scraping over all suspicious parts.

The articular surface of the posterior ligament must be exposed, and also freed of all degenerate and pulpy tissue.

This ligament should not be divided, nor should any opening, if possible, be made into the popliteal space.

When the inter-articular district has been completed, and the work of the scalpel or scissors followed up by the sharp spoon, until no trace of disease has been left behind, the surgeon turns to the anterior flap.

All the synovial membrane which covers this flap should be dissected off, the subcrural bursa must be fully opened up, and its lining membrane treated in the same way. Every nook and cranny must be patiently explored, and every fragment of tubercular tissue removed. The complete removal of every scrap of diseased tissue from the subcrural bursa is very important.

Here again, also, the erasion must be completed with the

sharp spoon, and every neglected point and corner subjected to a careful and complete scraping.

Finally, the cartilages and bones must be well examined. Patches of softened or eroded cartilage may be sliced off, and points of caries in the bones freely removed with the gouge.

The bleeding is arrested by the pressure of a sponge, which is maintained as long as possible, and by means of pressure forceps. Ligatures are but seldom required.

The articulation is then well washed out with some antiseptic solution (*e.g.*, carbolic solution, 1 in 40), well sponged, and dried.

The limb is placed upon the splint prepared for it, and the patellar ligament having been united by many points of chromicised catgut the wound is closed with silkworm gut.

Drainage-tubes should be avoided whenever possible, and in a large percentage of the cases they can be dispensed with, provided that the margins of the wound are not too closely approximated.

If drains be considered necessary, one should be inserted into the posterior angle of the wound on each side.

The tubes should be removed within forty-eight hours. The best dressing is formed of sponges dusted with iodoform. A layer of cotton-wool and gauze may cover the sponges, and then the whole dressing is secured with a tightly-drawn flannel bandage, so that good pressure may be brought to bear upon the part.

Mr. Barker's method of removing diseased tissue in chronic joint affections by means of his flushing-gouge is described in connection with excision of the hip (page 704).

The Operation (*as applied to the ankle*).—The method of Brüns is the best, and is described in the *Münchener Med. Wochenschrift* No. 24, 1891.

Two vertical incisions are made in front of the ankle, each commencing about 4 c.m. above the line of the joint and carried down in front of the corresponding malleolus to the level of the medio-tarsal joint. Through these incisions the anterior part of the ankle joint is dealt with.

Two posterior vertical incisions are then made, one on each side of the tendo Achillis, and through these the hinder part of the articulation is treated.

Comment.—The removal of the diseased tissue must be precise and complete. The operator must be able to recognise healthy tissue from that implicated by the disease, and success is never encouraged by violent and indiscriminate scraping.

In gouging bone it must be remembered that all softened bone is not necessarily carious, and that simply because a district of cancellous bone yields to the gouge it must not be assumed that it is hopelessly diseased.

The use of the actual cautery should be avoided. It interferes with primary healing.

It is important that the crucial ligaments be preserved.

The practice of making a hole through the posterior ligament, and of introducing a drainage-tube which traverses the popliteal space and escapes by the skin of the ham, is to be condemned.

If the wound be carried far enough back, drainage by two lateral tubes will be found to be ample.

After-treatment. — This closely follows the treatment observed after excision of the knee.

The limb should be supported by a back splint, which extends from the fold of the nates to beyond the heel, and terminates in a rectangular foot-piece.

Such an apparatus may be supplemented by a side splint if needed. The limb should be raised.

Dry and infrequent dressings are to be recommended.

As soon as the wound has soundly healed, a Thomas's splint may be applied, and the patient be allowed to go about with the aid of crutches and a patten.

A rigid apparatus must be kept applied to the limb for a considerable time after all appears sound and well. "As in excision, flexion will occur unless the limb is kept fixed for from two to three years at least." Thus writes Mr. Wright in 1888.

Results.—"The results," says Mr. Wright, "in successful cases are better than those of excision, in that there is no shortening whatever, either immediate or as growth goes on, while the results in other respects are like those of excision, for a firm, stiff, straight limb is obtained. Mobility, though

possible, is not to be counted upon. . . . Cases of both erasion and excision require long watching, to prevent distortion, and there is little difference between the two in this respect."

The recovery is on the whole quicker, less painful, and less troublesome.

The risk to life involved by the operation is very small indeed. Testimony to the admirable results obtained by this operation has now been afforded by many surgeons, and its position may be considered to be firmly established.

CHAPTER XXI.

Excision of the Upper Jaw.

This operation is considered to refer usually to the removal of the superior maxillary bone of one side, but to include also the rarer operation in which both bones—and therefore the whole of the upper jaw—are excised at one sitting.

The operation has been performed for the relief of several conditions, but is at the present day almost limited to the treatment of malignant growths (epithelioma and sarcoma) which involve the upper maxilla.

The operations for the removal of innocent tumours are for the most part partial, and, indeed, the conditions must be very exceptional in which the excision of the entire bone on one side would be called for in dealing with an innocent growth.

Partial excisions, and the so-called osteo-plastic or temporary excision, are dealt with on page 725 *et seq.*, and in the subsequent chapter (page 729).

The value of the usual operation—viz., the removal of one superior maxilla for malignant disease—is a matter of question. Mr. Butlin is of opinion that, "unless there is a reasonable hope that better results will be procured in future, the operation must be condemned." The subject is further alluded to in the section on "Results."

The operation was originally proposed by Lizars in 1826 ("A System of Anatom. Plates," part ix., Edin., 1826), but was first carried out (independently of Lizars' suggestion) by Gensoul in 1827 (Lettre Chirurgicale, etc., Paris, 1833).

On many occasions previous to these dates portions of the upper jaw had been removed, or the contents of the antrum evacuated. The excision of both superior maxillary bones at one sitting appears to have been first accomplished by Heyfelder in 1844.

Anatomical Points.—The details of the anatomy of the superior maxillary bone must be borne in mind as well as its relations to surrounding parts. The bone forms the largest part of the face, of the outer wall of the nose, of the roof of the mouth, and of the floor of the orbit. The bone as a whole is thin and shell-like, its most substantial part being the malar process. It articulates with nine bones, and no less than nine muscles are attached to it.

The bony connections to be dealt with in the operation are the following:—(1) The connection with the malar bone at the outer side of the orbit; (2) the connection of the nasal process with the frontal, nasal, and lachrymal bones; (3) the connections of the orbital plate with the ethmoid and palate; (4) the connection with the opposite bone, and with the palate in the roof of the mouth; and (5) the connection behind with the palate bone and the fibrous attachments to the pterygoid processes.

In excising the bone in the living subject, the upper part of the nasal process is usually left behind, the malar bone is divided, and a portion of it removed with the maxilla. The inferior turbinated bone is of course included in the parts excised, and also the whole or the greater part of the palate bone.

In cutting through the nasal process the lachrymal sac will be damaged, and the nasal duct cut across.

The attachments of the soft palate to the palate bone must be severed.

The blood-vessels which are concerned in the operation are certain branches of the facial artery, the infraorbital artery, the alveolar branch of the internal maxillary, the descending palatine, pterygo-palatine, and spheno-palatine arteries, and the deep facial vein.

All these vessels are, under normal conditions, small.

Instruments Required:—Gag; tracheotomy tube; scalpels; tooth forceps; bone-cutting forceps of various patterns; sequestrum forceps; lion forceps; volsella; metacarpal saw; chisel and mallet; rugine; periosteal elevator; strong scissors, both straight and curved on the flat; dissecting, artery, and pressure forceps; Paquelin's cautery; harelip pins, needles, sutures, etc.; sponge-holders.

Preliminary Measures.—During the performance of the operation considerable danger may be incurred from hæmorrhage. Not only may the bleeding be copious in amount, but the blood may readily find its way into the air-passages.

Various measures have been adopted to meet this complication. Lizars in his first operation ligatured the internal maxillary and temporal arteries as a preliminary step. In his second case he secured the external carotid. With a like object in view, a ligature of the common carotid has been both advised and carried out.

Professor Rose advises that the head be so far thrown back that the vertex looks towards the ground, and points out that in that attitude the blood can only occupy the upper part of the pharynx, and must escape through the wound and the nose.

The position, however, is most inconvenient to the surgeon, it does not prove so efficacious as it may appear, and it leads to considerable venous congestion of the head and face.

Some operators make a practice of performing tracheotomy, and of then plugging the larynx with a piece of fine Turkey sponge to which a tape is attached; or they make use of Trendelenburg's tracheal tampon-cannula.

In connection with this matter I would say that the preliminary ligature of a main artery is not a necessary or desirable proceeding. Should, however, the tumour be exceedingly vascular, *e.g.*, suppose it to be an extensive angeioma, a temporary loop may be placed around the external carotid artery. This loop could be drawn upon during the operation, and removed when the bleeding had been dealt with.

I have used Trendelenburg's cannula in many operations within the mouth, and have found it always to effect its purpose. Care should be taken to test the instrument before it is employed. The thin india-rubber tissue which forms the tampon soon perishes, and should be replaced every time the instrument is used. Even if this cannula be employed, it is necessary to place a sponge over the larynx, as a considerable clot may form in the laryngeal cavity above the tampon. It may be here observed that if the cannula be retained for

some time after the operation, as a precaution in the event of secondary bleeding occurring, it will probably be found to be no longer of effect in plugging the trachea. If the instrument be retained, the india-rubber tissue is very apt to become disorganised; and in the case of one cannula which had been retained only forty-eight hours I found the tampon on removal to be represented only by mere shreds of india-rubber.

The question of a suitable tampon-cannula, and the use of Hahn's cannula, will be found discussed in the section on the "plugging of the trachea" as a preliminary to excision of the larynx (vol. ii., page 151).

In the majority of cases, neither the preliminary ligature of an artery, nor a preliminary tracheotomy is necessary.

If, on the other hand, the posterior nares be carefully plugged before the operation, if the division of the palate be left to the last, if the latter stages of the operation be rapidly executed, and if an assistant is very ready with pressure forceps and sponges, it will usually be found that the bleeding can be efficiently dealt with.

It is needless to point out that a tracheotomy, or a wound to expose the carotid artery, adds another danger to a proceeding already formidable enough.

COMPLETE OPERATIONS.

The many different methods described for excising this bone are distinguished from one another by little else than the disposition of the skin incision.

The following operations will be described. The first represents what may be conveniently called the median incision, the second represents the cheek incision, and the third the method of exposing the jaw through a flap:—

1. The operation by a median incision.
2. Velpeau's operation.
3. Langenbeck's operation.
4. Other methods.

1. The Operation by a Median Incision.

This procedure forms without doubt the best measure for excising the superior maxilla.

The operation is known in most French text-books as

Nélaton's or Liston's operation, and in most English books as Fergusson's operation.

The exact methods carried out by Liston and Fergusson are alluded to in a later section. The present operation would appear to have originated with Blandin (" Anat. Topograph.," 1834, page 122).

The patient lies upon the back, with the head and shoulders well raised. The face, if the patient be a male, should have been already shaved. The head is turned to the sound side.

The surgeon stands on the patient's right-hand side in dealing with either side of the jaw. The chief assistant should take his place opposite to him. Another assistant may stand by the surgeon's side. The posterior nares are well plugged.

1. The incision is commenced at a point half an inch below the inner canthus, is carried down by the side of the nose—where the nose joins the face—follows the groove which limits the ala nasi, and, skirting the nostril, reaches the median line of the lip.

While this cut is being made, an assistant may compress the facial artery.

When the lip is reached, the chief assistant grasps each extremity of the lip (at either angle of the mouth) between the finger and thumb, so as to compress the coronary arteries. The incision is then carried through the median line of the upper lip into the mouth (Fig. 213, A).

The superior coronary arteries are at once seized and secured.

While dealing with the lip the upper part of the wound is being compressed by a sponge.

In this stage of the operation the following vessels are divided:—The angular artery and the large angular vein, the lateralis nasi artery, the superior coronary, the artery to the nasal septum, and some trifling branches of the infraorbital.

2. A second incision is now carried along the lower margin of the orbit. At its commencement it starts from the point of the first incision, and ends over the malar bone (Fig. 213, A).

3. The cheek flap thus marked out is now rapidly raised

from the bone, and should contain all the soft parts down to the maxilla. No attempt should be made to save the periosteum. In dissecting up this flap the infraorbital artery is divided. Care should be taken that no blood runs into the mouth, and an assistant should follow the flap with a sponge.

Throughout the operation sponge pressure is the main means of checking hæmorrhage.

4. The operator should now separate the nasal cartilages from the bone, and should then divide the nasal process. This may be done with a fine saw or a chisel (Fig. 215, A). He should next proceed to divide the periosteum along the lower edge of the orbit. With the elevator the periosteum of the floor of the orbit is carefully raised, and in effecting this the origin of the inferior oblique muscle is separated.

With a fine chisel the orbital plate may be divided as far within the orbit as is necessary. The chisel-cut will commence at the point at which the nasal process of the maxilla has been divided, and will end at the spheno-maxillary fissure (Fig. 215). If it be considered necessary to take away the whole of the orbital plate of the maxilla, then a chisel-cut can scarcely avail, and the bone must be wrenched away from its attachments in the final act of removal.

The last step of this stage of the operation is to divide the malar bone. This may be done with a chisel or a small saw. The malar bone is divided obliquely (from above downwards and outwards) at a point about the centre of the bone, and the saw or chisel is so applied that the section will extend into the spheno-maxillary fissure, the exact site of which should have been previously defined (Fig. 215, B).

5. The palate part of the bone alone remains with its connections undisturbed. The mouth having been well opened, the central incisor tooth on the diseased side is removed, the muco-periosteal covering of the hard palate is divided in the median line, and a knife is drawn along the floor of the nose from before backwards, and as near as possible to the septum. By means of a transverse incision made through the mouth, the soft palate is loosely separated from the hard.

A key-hole saw is now introduced through the nose, and the bony palate divided as near to the median line as is

possible (Fig. 215, C). This step of the operation should be rapidly performed, as there is often much bleeding from the palatine arteries, which are necessarily divided.

6. The surgeon finally grasps the bone with lion forceps, holding the instrument with its blades opened vertically. One blade takes hold of the orbital plate, and the other of the alveolus. The maxilla is then wrenched from its few remaining attachments. These will, in part, concern the orbital plate, and in part the attachment existing between the maxilla and the pterygoid process. The separation of the bone from the last-named process may be aided by bone-cutting forceps bent at an angle, and introduced behind the maxillary tuberosity.

Care must be taken at this stage that the soft palate is freed completely from its connections with the hard.

Without bringing much force to bear upon the forceps the bone is finally removed.

7. Any bleeding from the depths of the cavity should now be checked so far as is possible.

It will usually be desirable to plug the cavity with gauze. Carbolised iodoform, or alembroth gauze may be employed. The amount introduced must be noted, and the ends of the strips so placed that they can be readily reached from the mouth.

Fig. 213.—EXCISION OF THE UPPER JAW.
A, By a median incision; B, By Velpeau's method; C, Excision of the lower jaw.

A silk thread may be attached to the end of each strip, and brought out of the mouth and fastened to the cheek.

The actual cautery may sometimes be used with good effect to check the hæmorrhage.

The skin wound is finally united very carefully with

silkworm-gut sutures, especial care being taken to accurately adjust the red margin of the lip. No harelip pins are necessary in any ordinary case.

The wound is finally well dusted with iodoform, and dressed with a sponge held in place by a flannel bandage.

Comment.—This operation has the following great advantages:—The bone is well exposed, and plenty of room is provided for its excision, the vessels and nerves are cut at a distance from their trunks, the salivary duct is not interfered with, and the scar is so placed as to produce but little deformity. The operation, moreover, allows of easy control of the hæmorrhage.

In the matter of the resulting deformity Mr. Butlin observes ("Operative Surgery of Malignant Disease," 1887, page 128):—"When the lower margin of the orbit has been removed, the lower eyelid often swells, becomes red and œdematous, and may remain so in spite of every means taken to relieve it. The disfigurement produced by this cause is very marked."

If the posterior nares be plugged, and if the steps of the operation be followed in the order given, no blood should find its way into the mouth until the last stages of the excision are reached. Farabeuf does not divide the lip until towards the last. His first incision ends at the ala of the nostril. The nasal, orbital, and malar parts of the bone are separated. The cut is finally carried through the lip, and the palate segment of the bone dealt with.

In many text-books the removal of the incisor tooth is one of the first steps of the operation. This is not necessary, and blood from the socket of the tooth, running into the mouth, may add a needless complication to the procedure.

The excision should be carried out rapidly, but without haste, and above all without violence.

The connections of the bone must be well freed before an attempt should be made to wrench it away.

Carefully-applied pressure with fine Turkey sponge affords the best means throughout the operation of dealing with hæmorrhage.

It is useless to make any attempt to save the muco-periosteal covering of the hard palate.

French surgeons usually employ a chain-saw to divide the malar bone. The saw is conducted into position by means of a curved needle, which is passed through the spheno-maxillary fissure.

It not infrequently happens that the bone breaks up during removal, and has then to be taken away in fragments.

After the removal of the maxilla the cavity should be examined for any traces of the growth. It is apt to spread to the pterygoid plates, which need very careful inspection.

2. **Velpeau's Operation.**

In this operation the incision is commenced at the angle of the mouth, and is carried, in a curved direction, through the cheek to end over the centre of the malar bone (Fig. 213, B). The incision is carried directly into the mouth, and the flap thus formed is turned inwards.

The operation is completed precisely in the manner already described.

Comment.—This incision is a modification of that originally proposed by Lizars.

Compared with the previous operation it has these disadvantages:—The bone is not so readily exposed, and there is greater difficulty in dealing with its orbital and nasal portions. The arteries of the face are divided nearer to the trunk. The parotid duct is wounded. An ugly scar results.

The measure, however, is of value in cases in which the cheek is to a small extent invaded, and in which it is possible that the involved skin can be removed by widening the cut at the necessary spot.

The question, however, would remain as to whether an operation would be justifiable in such a case.

This procedure was followed by Warren, Ballingall, and others, and is still advised by Ollier.

3. **Langenbeck's Operation.**

In this method the skin incision commences at the side of the nose, at the junction of the nasal cartilage with the nasal bone. It then passes with a downward convexity to the junction of the upper lip with the cheek, and is finally carried upwards and outwards to end over the middle of the malar bone. In this way a large U-shaped flap is formed (Fig. 214, A)

The incision is carried down to the bone, and the flap reflected upwards and outwards. The operation is completed in the manner already described.

Comment.—But a comparatively small space is afforded by this method, and while the procedure is not ill-adapted for some partial operations, it is not convenient when the whole bone has to be removed.

Fig. 214.—EXCISION OF THE UPPER JAW. A, By Langenbeck's method; B, By Gensoul's method.

The duct of the parotid gland is cut, and many branches of the facial nerve are divided.

The resulting scar is very unsightly.

The advantages claimed for the method are the following:—The lip is not divided, and therefore the form of the mouth is preserved. The incision may be so placed that the trunk of the facial artery is avoided.

4. Other Methods.

Liston made use of three incisions. (1) A cut from the external angular process of the frontal bone through the cheek to the angle of the mouth. (2) A short incision along the zygoma to meet the first incision. (3) A cut along the side of the nose and through the centre of the lip (*Lancet*, March, 1836; and "Practical Surgery," 2nd ed., 1838, page 279).

Fergusson made the same naso-labial incision as Liston, carrying the cut up to within half an inch of the inner canthus. He made a second incision from the angle of the mouth to the malar bone, and, if needed, a third incision at right angles to the outer extremity of the buccal wound (*Lancet*, March, 1842; and "Practical Surgery," 2nd ed., 1846, page 550).

Gensoul's incisions were remarkable. One was carried

vertically downwards from the level of the inner canthus to divide the lip opposite to the bicuspid tooth; a second cut started at right angles to the first at the level of the floor of the nose; and a third was carried upwards in front of the ear to the external angular process of the frontal bone (Fig. 214, B).

Comment.—These methods are enumerated in order to make clear the precise operations adopted by surgeons whose names are somewhat loosely employed in connection with excision of the jaw.

Gensoul was the first surgeon to remove the superior maxilla.

These historical operations have all been replaced by more practical measures.

Fig. 215.—SAW INCISIONS IN THE MAXILLÆ.

A, B, C, Excision of upper jaw; D, Poeckel's operation (nasal polypus); E, C, Guérin's operation (partial excision); F, F, Langenbeck's operation (nasal polypus); G, Excision of lower jaw; H, Removal of portion of alveolus; I, Esmarch's operation (anchylosis of jaw).

PARTIAL OPERATIONS.

1. The alveolar part of the bone and the palate process may be readily removed through the mouth without making any incision in the skin. The upper lip is everted, and is either held up by suitable forceps or drawn up by retractors. The tissues of the cheek can, if needed, be separated to the required extent from the bone by dividing the mucous membrane along the line at which it is reflected from

the cheek to the maxilla. The division of the bone is best accomplished by a chisel and mallet, the section being made horizontally. If the reflection of the soft parts be carried up to the level of the floor of the nares, the nasal cavity can be readily opened up from the mouth.

The broad rectangular retractor used in certain abdominal operations is very useful in holding up the tissues of the cheek.

2. If it be considered desirable to remove all that portion of the superior maxilla which lies below the infraorbital foramen, the operation introduced by Guérin (" Éléments de Chirur. Opérat.," 6th ed., 1881, page 267) may be carried out. This procedure was modified later by Maisonneuve, and is sometimes known as Maisonneuve's operation.

An incision, with the convexity outwards, is made from the ala of the nose to the angle of the mouth, and is so placed as to follow the line of the features (Fig. 219, B). The soft parts are dissected up, and the nostril opened. The malar process of the superior maxilla is laid bare. A narrow saw is now introduced into the nose, and is made to saw the whole maxilla in a horizontal line. The saw-cut passes below the infraorbital canal and well above the teeth, and escapes externally through the maxillary tuberosity (Fig. 215, E). The next step is to detach the soft palate from the hard through the mouth, by means of a transverse incision made at the level of the last molar tooth. A middle incisor tooth having been removed, the hard palate is divided in the median line by a narrow saw introduced through the nose (Fig. 215, C). The piece of bone thus isolated is then loosened by an elevator and wrenched out with the lion forceps. Guérin made large use of cutting forceps, but at the present day both saw and forceps would probably be replaced by the chisel. This operation is said to have been followed by excellent results, and to have led to but little deformity.

3. If the whole of the maxilla be removed with the exception of the orbital plate, the median incision should be employed, with the omission of the horizontal suborbital part of the cut. The nasal process of the maxilla is divided close to its origin from the main bone. A horizontal cut is made with the chisel through the jaw between the orbital margin

and the infraorbital foramen, and the malar bone is divided obliquely close to its articulation with the maxilla.

4. When the orbital and nasal parts of the upper jaw are involved, and the lower alveolar portion is sound, the latter may be preserved by the method thus described by Mr. Jacobson:—"A cheek-flap being reflected by an incision through the lip and upwards to the inner canthus along the nose, the nasal and malar processes are divided, while the eye is duly protected. A horizontal saw-cut is then made above the alveolar process, outwards from the nose, and another carried upwards from the outer end of this, to join the incision through the malar process, being made either with the saw or chisel. The piece of bone thus mapped out is loosened with a chisel or elevator, and either prised out with the latter instrument or wrenched downwards and outwards with the lion forceps." (*See* "The Operations of Surgery," 1889, page 296.)

THE REMOVAL OF BOTH SUPERIOR MAXILLÆ.

This operation, which can but very rarely indeed be justifiable in actual practice, may be carried out by means of the median incision performed upon either side of the nose, just as in removing either the left or the right bone.

The steps of the proceeding are similar to those already described, save that the palate process is now divided with the saw.

THE AFTER-TREATMENT.

The gauze plug employed should not be large enough to bulge out the cheek and cause a strain upon the sutures. It should be removed in twenty-four hours, as it soon becomes offensive if retained.

Every possible care should be taken that the mouth and the wound cavity are kept clean.

The patient should be raised up in bed by means of a bed-rest, so as to facilitate the escape of discharges. He should rinse out the mouth very frequently with some antiseptic solution. Carbolic acid (1 in 60 or 80) answers admirably. Twice or three times a day also the cavity should be well washed out with a like solution from an irrigator provided with a wide-mouthed nozzle.

The surface wound should be kept dry, and dusted with iodoform.

The feeding of the patient is a matter of the greatest importance. He may be fed for the first day or two with the œsophageal tube. Through this tube, milk, beaten-up eggs, beef-tea, and brandy can be administered as frequently as desired.

Fig. 216.—ASPECT OF PATIENT AFTER REMOVAL OF THE UPPER JAW ON BOTH SIDES. (*After Braun.*)

If necessary, this mode of taking nourishment may be supplemented by nutrient enemata.

When the patient can swallow food without assistance—and he may be able to do so from the first—the mouth must be washed out after each time food is taken.

The skin wound generally heals well enough, and, if no complications arise, the patient may be up in a fortnight.

When the wound is quite sound, the question of fitting an artificial palate or tooth-plate has to be considered.

Results.—Mr. Butlin has very fully investigated the results of this operation, basing his conclusions upon the study of 108 cases. He gives the immediate mortality of the operation as 30 per cent. The causes of death—in order of frequency—are exhaustion, erysipelas or pyæmia, lung troubles, meningitis.

Most of the operations were performed for malignant disease, with the terrible result that only four can be claimed to have been successful—*i.e.*, to have exhibited no return after an interval of three years.

Dr. Joseph Bryant (*Annals of Surgery*, May, 1890) claims that the immediate mortality of the operation is only 14 per cent. He founds this statement upon an analysis of 230 cases, but the observation is not supported with sufficient detail. The terrible deformity which may be expected to result when both bones are removed is illustrated by the case depicted in Fig. 216.

CHAPTER XXII.

OPERATIONS UPON THE UPPER JAW IN CONNECTION WITH THE TREATMENT OF NASO-PHARYNGEAL POLYPUS.

OSTEO-PLASTIC RESECTION OF THE UPPER JAW.

THE naso-pharyngeal polyp, with which these operations are concerned, is that fibrous or sarcomatous growth which, taking origin from the roof of the pharynx or nasal cavity, is apt to grow almost without limit, to fill the naso-pharyngeal space, to displace and thin the facial bones, and to give rise to considerable hæmorrhage. The actual method employed to remove these growths when they have been exposed is a matter of comparatively small importance, and will vary with the practice of each individual surgeon. Some advocate avulsion—*i.e.*, the grasping of the pedicle of the tumour and its removal by tearing; others employ the ligature, or the wire écraseur; some make use of the galvanic loop; and others detach the base of the growth by means of a rugine.

The difficulty is not in dealing with the base or pedicle of the tumour, but in exposing it. If only the root or point of origin of the polyp can be reached, the main problem in the matter of treatment will be solved.

The operations which are about to be described have simply for their object the proper exposure of the pedicle of the polyp, or such exposure as will enable the root of the growth to be dealt with.

It cannot be said that on the whole they are very satisfactory procedures, but on the other hand it must be acknowledged that the difficulties to be surmounted are considerable.

Some of the operations consist in removing portions of the superior maxilla. In not a few instances the whole of the bone upon one side has been sacrificed in order to expose the pedicle of the tumour. Other measures consist in partially

separating some portion of the bone, and in replacing it after the growth has been dealt with. These operations are generally included under the terms osteo-plastic resection, temporary resection, "luxation temporaire."

The origin of the osteo-plastic resection is ascribed to Huguier about 1852 and 1854, and the first operations appear to have been performed by himself and by Langenbeck in 1861—a different method, however, having been adopted by each.

These various operations are attended with considerable danger in the severer class of case. The main trouble is from hæmorrhage, which may be desperate.

In cases in which much bleeding is anticipated, and in which the growth is large and prominent towards the pharynx, it is the usual practice to perform laryngotomy or tracheotomy, and to plug the opening of the larynx, or to use a Trendelenburg's tampon. (*See* page 717.)

Not a few patients have died of meningitis. Others have succumbed to septicæmia, or have died apparently of mere exhaustion. A recurrence of the growth has been common.

The retro-maxillary region may be reached in more than one way. It may be approached through the palate, or through the anterior wall of the nasal fossæ, or through the maxilla.

The operations about to be described will be divided into three categories, according as the pedicle of the polyp is approached or the naso-pharyngeal region entered—

1. By the palatine route.
2. By the nasal route.
3. By the maxillary route.

It will be seen that this division is convenient, although not anatomically very precise.

1. THE PALATINE ROUTE.

Nélaton's Operation.—The mouth having been widely opened by means of a Mason's gag, a median incision is made along the soft palate and uvula so as to bisect them completely. This incision is carried forwards upon the hard palate, until it reaches a point half-way to the alveolus. At the termination of this median cut, two transverse

incisions are made which incline a little backwards (Fig. 217, A).

The two flaps of muco-periosteum thus marked out upon the hard palate are now dissected up with the rugine. The soft palate is detached from the hard, and the exposed portion of the latter is then removed with the chisel and mallet in the form of a quadrilateral piece of bone. The nasal mucous membrane is divided, and as much of the vomer removed as is necessary. An entrance into the naso-pharyngeal region is thus effected. After the polyp has been dealt with, the cleft in the palate is closed by staphyloraphy. (See *Bull. de la Soc de Chir.*, t. i., page 159.)

Chalot's Operation. — The attachments of the upper lip are separated from the bone after the surgeon has divided transversely the fold of mucous membrane between the gum and the lip at the level of the anterior nasal spine. The nasal fossæ are opened in this way from the front.

The canine tooth on each side is in the next place removed.

The mouth is now well opened with a gag, and two incisions are made through the muco-periosteum of the hard palate. These incisions are placed one on each side. They start from the gap formed by the loss of the canine teeth, terminate behind, where the hard palate terminates, and in their course keep close to the alveolus (Fig. 217, B). The alveolus and the hard palate are now divided from before backwards in the line of this incision by means of a chisel and mallet.

The large piece of bone thus isolated is separated from its connections with the vomer and nasal mucous membrane, and is turned down into the mouth like a trap-door, the hinge of the door being at the junction of the hard palate with the velum.

After the polyp has been removed, the displaced bone is restored to its former position, and may be maintained there by a wire suture passed on either side through the alveolus (Chalot's "Nouveaux Éléments," Paris, 1886).

Comment. — It is claimed for these operations that

they leave no deformity of the face, and do not interfere with mastication. Nélaton's procedure is much the less severe, but very little room is provided for manipulation. The aperture made is some way back in the mouth, and a view of the operation area can only be obtained with much difficulty. In Chalot's operation, considerable injury

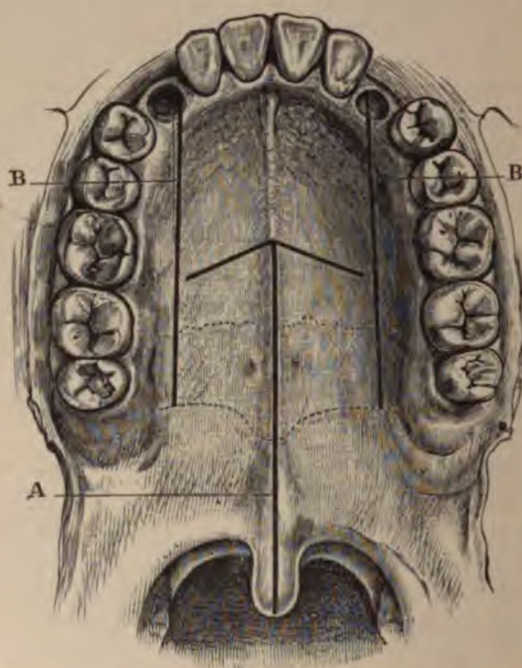

Fig. 217.—A, Nélaton's operation for nasal polypus; B, Chalot's operation for nasal polypus.

is inflicted upon the hard palate; but a larger opening is made, and it is placed well forwards, and therefore in a much more convenient situation. It will be obvious, however, that if much bleeding occur the displaced palate will form a very troublesome and obstructive foreign body in the mouth, and the operation could scarcely be safe unless a preliminary tracheotomy had been performed and the larynx plugged. These operations have not been very extensively employed. They are not suited for the larger

polypi, nor for those whose attachments are—as is usually the case—high up.

Annandale's Operation.—Professor Annandale has demonstrated (*Lancet*, January 26, 1889) that when the alveolar margin and palatal portions of the upper jaw have been divided along their centre from before backwards, and the bony septum of the nose cut through (the anterior nares having first been exposed by Rouge's plan), the two portions of the upper jaw can be separated to the extent of from half an inch to one inch, so as to give access to the posterior nares and base of the skull. Professor Annandale reports three examples of the operation. In one a preliminary tracheotomy was found necessary. All three patients recovered.

The following are the steps of the operation:—

1. The anterior nares are exposed by freely dividing the mucous membrane connecting the upper lip with the superior maxilla, and turning the lip upwards according to the plan of Rouge (page 736).

2. The bony septum of the nose is divided along its attachment to the maxilla with cutting forceps.

3. A gag having been introduced, an incision is made through the muco-periosteal covering of the hard palate in the median line. A key-hole saw is then introduced through the nose, and the alveolar margin of the upper jaw and the entire hard palate are sawn through in the same line. It may be necessary to extract an incisor to effect this. The soft palate may or may not require division. This will depend upon the size and attachments of the growth. In two of the reported cases it was divided; in one it was not.

4. The right and left halves of the maxilla are now forcibly separated, and by means of the finger or a periosteal elevator the secondary connections of the growth are freed.

5. Through the gap the polyp is now removed. For this purpose Annandale used strong forceps, assisted by a periosteal elevator and a sharp spoon.

6. When the tumour has been removed, a plug of lint soaked in carbolic acid and well dusted with iodoform is introduced into the cavity left by the removal of the polyp.

7. The two portions of the upper jaw are brought together again, and secured by one wire suture through the alveolar margin of the bone. The cleft in the soft palate is closed by two or more horse-hair sutures.

Comment. — This operation affords probably the most satisfactory method of reaching a naso-pharyngeal polyp from the palate. It does not involve a great disturbance of the parts, there is no loss of bone, and no deformity is produced. As the section is made in the median line, there is less bleeding. Should it become evident that a more extensive operation will have to be carried out, this procedure may be converted into the first step of an operation for the removal of the whole or a part of the maxilla. There are the objections that the surgeon has to operate in a confined space, and that the opening into the naso-pharynx is at a considerable distance from the usual site of the attachment of the tumour.

2. THE NASAL ROUTE.

Desprez's Operation. — In this operation the cartilaginous part of the nose is turned over to *one side*, its connections having been divided upon the opposite side. The surgeon first defines the margin of the bony nostril, *i.e.*, the lower border of the nasal bone and the free border of the nasal process of the maxilla.

The skin is incised on one side of the nose parallel to this line and a little below it. The incision commences near the middle line, is carried down to the groove which separates the cheek from the nostril, and is made to end in the orifice of the opposite side.

The cartilaginous part of the nose is now separated from the bony part by means of scissors curved on the flat; the nasal septum is separated at its inferior attachments as far as is needed, and the end of the nose thus freed is forced over to the opposite side. To obtain still more room, the turbinated bones may be removed in whole or in part.

After the polyp has been secured the nose is brought back into place, and the skin incision is carefully closed by sutures.

Lawrence's Operation. — In this procedure the nasal cavity is exposed by detaching the nose and turning it

upwards. An incision is made along each side of the nose, commencing at a point just internal to the lachrymal sac and terminating at the junction of the ala nasi and the lip. This incision is carried into the nasal cavity by cutting through the nasal bones and the nasal process of the maxilla with bone forceps.

The septum is next divided, and the nose is turned up so that the posterior part of the cavity can be reached. (See *Medical Times and Gazette,* 1862, vol. ii., page 491.)

Langenbeck's Operation.—The following brief account of this procedure is derived from Mr. Jacobson's work. Here also the displacement of the bones is *upwards.* The soft parts are divided by an incision reaching from the centre of the root of the nose obliquely downwards and outwards on one side of the nose on to the cheek, and ending at a point external to the ala nasi (Fig. 218, A). The soft parts on the upper lip of the wound having been raised upwards and outwards, a vertical incision is made upwards, through the nasal bone to the nasal spine of the frontal, and a second outwards from the bony margin of the anterior nares to the margin of the orbit. The nasal bone and the nasal process of the superior maxilla are then forcibly displaced upwards, together with their periosteum, being still connected with the frontal bone by skin, periosteum, and mucous membrane. When the polyp has been removed, the bones are replaced and the skin united by suture.

Fig. 218.—OPERATIONS FOR NASO-PHARYNGEAL POLYPUS.

A, Langenbeck's operation; B, Boeckel's operation.

Ollier's Operation.—In this measure the nose is separated and displaced *downwards.*

The incision commences in the groove where the ala joins the cheek, is carried up along the side of the nose, is then made to pass over the root of the nose between the eyes, and to follow a symmetrical course upon the other side of the face (Fig. 219, A).

A fine bone-saw is now taken, and the nasal bones are sawn in the line of the skin incision.

As large a section of the bones is made as is possible. Indeed, the saw may be carried sufficiently far back to just avoid the lachrymal sac and nasal duct. The nose thus separated is turned downwards. The septum is pressed aside, and the site of the operation reached. The operation is concluded by adjusting the part with sutures.

Comment.—Of the comparative merits of these various measures there is little to be said. As a whole, they must be of very limited application, and are suited rather for nasal than for naso-pharyngeal polypi. They provide but little room; and if the attachment of the growth be to the base of the skull, at the roof of the pharynx these operations can avail but little. If the attachment be to the anterior part of the nasal roof, however, one or other of these measures may be employed. The published cases are, up to the present time, very few.

Rouge's Operation.—This procedure may be conveniently considered in this place.

It affords a means of gaining a free access to the nasal cavities without making a scar upon the face.

The operation would scarcely be carried out in dealing with naso-pharyngeal polypi, except in cases in which the growth was very small, and easily reached from the front. It is, however, of admirable service in dealing with cases of obstinate ozæna, in affording a means of fully examining the nasal cavities, in removing carious bone, in dealing with lupus of the nasal mucous membrane, and in treating the more troublesome forms of nasal polypus.

The operation was described by Dr. Rouge in 1873 ("Nouvelle Méthode pour le Traitement Chirurgical de l'Ozène," Lausanne, 1873).

Precautions having been taken to prevent the flow of blood into the pharynx and larynx, the upper lip is forcibly

raised by an assistant, who, leaning over the patient's head, draws up the lip by taking hold of it at the angles of the mouth.

The surgeon, with scissors curved on the flat, frees it from the maxilla by cutting the mucous membrane along its line of reflection, from opposite the bicuspids of one side to a corresponding point on the other. The scissors must be kept close to the bone. The cartilaginous septum is next detached from the anterior nasal spine, and the alar cartilages are separated from their connections with the maxilla. The adjacent parts of the cheek must be separated as far as is necessary, in order that the upper lip, together with the nose, may be turned upwards towards the forehead, and the anterior nares well exposed for examination.

After the operation the parts are merely replaced. No sutures are needed. The nose may be carefully and accurately supported by means of cotton-wool and a bandage, and the mouth should be kept clean by some antiseptic wash.

Fig. 219.—OPERATIONS FOR NASO-PHARYNGEAL POLYPUS.

A, Ollier's operation; B, Guérin's operation; C, Langenbeck's operation.

3. THE MAXILLARY ROUTE.

Boeckel's Operation.—In performing this operation a considerable part of the bone around the margin of one nostril is sacrificed.

The skin incision commences near the root of the nose, and is carried obliquely along the side of the nose to the groove between the nostril and the cheek. It is then made to curve backwards and downwards for some little way upon the cheek. From the point of commencement of the incision

another cut is carried inwards, which follows the lower margin of the orbit. A tongue-shaped flap of skin is thus defined, the base of which is outwards (Fig. 218, B).

The incision is carried well down to the bone throughout. With a small rugine the periosteum is separated from the lower part of the nasal bone, and from the whole width of the nasal process of the maxilla, care being taken to avoid the lachrymal sac on the one hand, and the infraorbital nerve on the other. A chisel is now entered—first to the inner side of the infraorbital canal, and the maxilla is divided nearly vertically, the incision involving the whole of the wide base of the nasal process and a little of the bone beyond. This chisel-cut extends into the nasal cavity, reaching it to its floor.

The bone is now divided with the chisel just in front of the lachrymal sac, and again through the upper part of the nasal process and the lower part of the nasal bone, the instrument once more reaching the cavity of the nose. The portion of bone thus marked out is now entirely removed. The lines of the bone incisions and the part excised are shown in Fig. 215, D. The portion removed measures about 3 c.m. in vertical length, and about 2 c.m. in width.

The nasal cavity is now extensively exposed, and to obtain more room the inferior and middle turbinated bones are removed. After the polyp has been dealt with, the flap, composed of the periosteum and the soft parts, is carefully brought into position by means of sutures.

Langenbeck's Operation. — A tongue-shaped flap is marked out from the tissues of the face; a large part of the maxilla is separated by the saw, and the fragment, together with the soft parts which cover it, is temporarily displaced inwards. The following are the steps of the operation:—

Two semilunar incisions, both convex downwards, are made across the face. They are widely separated towards the middle line, but meet externally. The upper of the two incisions starts from the root of the nose, is carried just below the inferior margin of the orbit, and ends a little behind the middle of the malar bone. The lower cut starts from the ala of the nose, and, curving across the cheek, joins the termination of the upper incision.

The outer end of the united incision may be then continued a little way along the zygomatic arch (Fig. 219, C).

The knife is carried throughout well down to the bone. The integument should not be reflected, nor even disturbed. By means of a rugine the periosteum is freed along the lines of the incisions, and is, moreover, stripped from the floor of the orbit as far back as the spheno-maxillary fissure. The origin of the masseter is detached from the exposed part of the malar bone. The soft parts are left almost entirely undisturbed, and the flap must not be detached from the subjacent bone in any way.

A pointed elevator is now passed below the zygomatic arch, and is made to travel horizontally through the pterygo-maxillary fissure to the outer wall of the nasal cavity. Its end may be made out by the forefinger introduced through the mouth.

The elevator having been withdrawn, a key-hole saw, with the cutting edge upwards, is inserted along the tract made by the elevator, and is made to divide the zygomatic arch, as represented by the malar bone, and is so carried through that bone as to enter the spheno-maxillary fissure. It should then follow the floor of the orbit, to end short of the lachrymal bone (Fig. 215, F).

(As an alternative, the bone may be divided in the line of the skin cut, and the orbital plate thus spared.)

The saw is removed, and is once more introduced through the pterygo-maxillary fissure, but now with the cutting edge downwards. It is made to saw through the walls of the antrum, and to enter the anterior nares close to the nasal floor. It follows very nearly the line of the lower skin incision.

An elevator is once more introduced into the pterygo-maxillary fissure, and the portion of the maxilla separated is displaced inwards, together with the skin and periosteum which cover it.

The nasal bone and the nasal process of the maxilla form the hinge about which this large fragment is bent (Fig. 215, F F).

The piece is displaced upwards and inwards until the free portion of the malar bone is about in the middle of the

face. The naso-pharyngeal cavity is now well exposed. After the polypus has been removed the bone is replaced, and the wound closed by many points of suture. No sutures are, as a rule, needed for the bone. Its slight tendency to rise up can be met by the pressure of a sponge. No drainage-tube is required. A chisel may be employed in the place of the saw. As the bones are often much thinned by the pressure of the tumour, certain of the steps of the operation may be simplified.

Other Operations. — Naso-pharyngeal polypi have been exposed through the maxilla by removing other segments of the bone. The partial excision practised by Guérin, and described on page 726, has been not infrequently made use of in this connection.

The whole of the maxilla has been excised for the purpose of exposing a naso-pharyngeal polyp. For the same purpose the whole bone has been loosened from its connections, and has been replaced after the polyp had been removed.

Comment.—The two operations described provide a very fair view of the upper naso-pharyngeal region. The operation of Boeckel is simpler, and possibly less dangerous, but it provides less room for dealing with the polypoid growth.

Langenbeck's operation has been extensively employed, and is probably, of the various methods described, the one most frequently carried out.

The operation is difficult and tedious, and may be attended by very considerable bleeding.

In both these procedures the alveolus and the palate are left undisturbed. The oral cavity is not interfered with, and the orbital cavity is not seriously encroached upon. In both cases, however, a very conspicuous scar must result.

Results.—So far as the complete removal of the polyp is concerned, the best results have followed those operations which have given the widest view of the naso-pharyngeal region. Certain of the measures above described provide but little room, and much of the surgeon's work is done in the dark. The displaced piece of bone—in the so-called osteoplastic resections—has necrosed in whole or in part. Some patients have died of the immediate effects of the operation, the most serious element being hæmorrhage; others have

succumbed to meningitis, others to pyæmia. The mortality of these operations has been roughly estimated at about twenty-five per cent.

It must be confessed that recurrence, even after what appears to be a very complete removal, is common.

Out of thirty-nine operation cases collected by Lincoln, recurrence took place within twelve months in fourteen cases, eight deaths followed the operation, four patients may be said to have been cured, and in thirteen the conclusion of the case is not noted.

CHAPTER XXIII.

Excision of the Lower Jaw.

The circumstances under which this operation is carried out are nearly identical with those which justify like excisions of the upper jaw (page 715).

A large number of the operations are partial, and only in a few instances is it necessary to remove the entire bone, *i.e.*, both the right and left portions of the maxilla.

A concise account of the history of the operation is given by South (Chelius's "Surgery," vol. ii.). Deadrick (*Amer. Med. Rec.*, vol. vi., page 516, 1826) was the first who, in 1810, cut away the side of the lower jaw; in 1812 Dupuytren (Clinical Lecture, transl. in *Lancet*, vol. i., 1833, page 56) sawed off a large portion of the front of the jaw; in 1816 Anthony White (Chelius, vol. ii., page 991) removed half a necrosed jaw from the socket; in 1818 Astley Cooper ("Surgical Essays," part i., page 179, 1818) sawed off the projecting part of the chin; in 1821 Graefe (*Graefe and Von Walther's Journ.*, vol. iii., page 250, 1822) removed the front of the jaw, and in the same year one half of the lower jaw, which he exarticulated, and the patient lived. Mott's first operation, in which half the jaw was removed, by sawing through the chin and across the ascending branch, was performed in March, 1822 (*New York Med. and Phys. Journ.*, vol. i., page 386); his second, in which he exarticulated one half, in May, 1822, the patient dying on the evening of the fourth day.

Anatomical Points.—The general features of the bone and of the muscles attached to it need not here be considered. The maxilla is composed of very dense hard bone, which is somewhat difficult to saw or to cut with bone forceps. The bone is weakest at the situation of the bicuspid teeth, and strongest at the symphysis. Of the sockets for the teeth,

those for the incisors are the smallest, that for the canine is the widest and the deepest.

It must be remembered that with the loss of the teeth by age the alveolar part of the bone becomes absorbed.

The parotid gland is in close relation with the temporo-maxillary joint and the vertical ramus of the jaw.

The course of Stenson's duct across the massetèr is represented by a line drawn from the lower margin of the concha to a point midway between the ala of the nose and the red margin of the lip. It lies about a finger's-breadth below the zygoma, having the transverse facial artery above it, and the facial nerve below it. The facial nerve is represented by a line drawn across the parotid gland, in a direction forwards and a little downwards, from the spot where the anterior border of the mastoid process meets the ear.

The facial artery crosses the lower border of the jaw at the anterior margin of the masseter muscle.

The vessels divided in excising the lower jaw are the facial, inferior coronary and labial (if the lip be severed), mental, masseteric, inferior dental, and mylo-hyoid.

The parts in danger of being damaged are the facial nerve, the internal maxillary artery, temporo-maxillary vein, auriculo-temporal nerve, external carotid artery, gustatory nerve, and the parotid, submaxillary, and sublingual glands.

Instruments Required.—The same as for excision of the upper jaw, with the addition of a small saw with a movable back, or a small Butcher's saw, and a needle in a handle for securing the tongue if necessary.

THE REMOVAL OF ONE HALF OF THE LOWER JAW.

Operation.—The patient lies upon the back, with the head and shoulders raised, and with the trunk close to the edge of the table. The surgeon stands on the side to be operated upon. Some find it more convenient to stand on the patient's right in dealing with either side of the maxilla.

The head is turned to the sound side. The chief assistant takes his place opposite to the surgeon. A second helper stands by the operator's side.

In male subjects the chin will have been already shaved.

1. A vertical incision is made through the tissues of

the chin, in the middle line, starting just below the lip, which is not divided. From the lower end of this another incision is carried along and just below the inferior border of the jaw for its entire length, and is then directed upwards along the posterior margin of the ascending ramus, to end opposite to the lobule of the ear (Fig. 213, C).

The incision is carried throughout down to the bone, except in one place, *viz.*, where the knife crosses the facial artery. Here the wound is only skin deep.

After the incision has been made, the surgeon returns to the spot indicated, exposes the facial artery by dissection, secures it between two ligatures, and divides it.

With a periosteal elevator or rugine the muscles attached to the external surface of the maxilla are rapidly separated from the bone, and are turned up with the integuments in the form of a flap. The separation is commenced at the symphysis, and carried backwards. The buccinator and masseter are peeled off from the bone in this part of the operation. The mental and masseteric arteries, together with some smaller branches, are divided at this stage.

It is desirable that the operator should keep close to the bone.

The cavity of the mouth is now opened by dividing the buccal mucous membrane at its junction with the alveolus.

2. The surgeon now extracts one of the incisor teeth—the lateral incisor as a rule—and with a key-hole saw divides the jaw vertically in the line of the gap (Fig. 215, G). It is often more convenient to saw the bone nearly through, and then to complete the section with suitable bone-cutting forceps. More or less of the genio-hyoid, genio-hyo-glossus, and digastric muscles will be disturbed in clearing the inner surface of the bone.

3. The anterior extremity of the divided maxilla is now drawn outwards, and with a blunt-pointed knife kept close to the bone the surgeon divides the attachment of the mylo-hyoid muscle. The internal pterygoid muscle is reached, and may be conveniently separated from the bone by means of a periosteal elevator. The lower border of the maxilla is twisted outwards, in order that the whole of the attachment of the internal pterygoid muscle may be dealt with.

The inferior dental artery and nerve are exposed and divided. In this part of the operation care must be taken to avoid injury to the sub-lingual and sub-maxillary glands.

4. The anterior part of the jaw is now forcibly depressed, in order to bring the coronoid process into view in the posterior part of the wound.

The tendon of the temporal muscle is divided, with scissors curved on the flat, as each part of the fibres of insertion is successively reached.

Some surgeons divide the coronoid process with a chisel and mallet, and subsequently dissect out the fragment of bone thus isolated.

The jaw is still further depressed, in order that the condyle may be brought into view.

The external pterygoid muscle is reached, and is detached with the elevator or divided with scissors. The capsule of the joint is severed, the articulation is opened and the condyle freed. Throughout this stage of the excision the jaw should be merely depressed. It should not be twisted. If it be much everted or rotated out, the internal maxillary artery may be brought into contact with the neck of the bone, and may be accidentally divided or even torn.

It only remains now to cut the bone free of its few surviving attachments, which are represented by the internal lateral, stylo-maxillary and pterygo-maxillary ligaments, together with more or less fascia and the remaining fibres of the outer pterygoid muscle.

All bleeding having been checked, the wound is united with silkworm-gut sutures. The chin part of the incision should be adjusted with especial care. A drainage-tube may be introduced into the hinder part of the wound, and retained there for twenty-four hours.

A dressing composed of a sponge dusted with iodoform, and kept in place by a layer of wool and a supporting bandage, will be found to be efficient.

Comment.—This operation admits of very little variation. The whole of one side of the maxilla has been removed with success, through the mouth.

Upon no reasonable grounds, however, can this method be recommended. It is true that no skin-wound is made, but

on the other hand the scar resulting from the usual wound is not disfiguring, nor is it even conspicuous. In attempting to remove the maxilla from the mouth, the surgeon must find his movements hampered. Considerable damage must be inflicted upon the soft parts; there is great risk of injuring the internal maxillary artery, and efficient drainage is not provided.

If the operation be carried out as advised, there can be little need of adopting such special measures for meeting hæmorrhage as the ligature of the external carotid artery, or the plugging of the larynx after tracheotomy. It is only when dealing with large and vascular growths that any such precautions are suggested.

Some surgeons carry the skin incision entirely through the lip. This procedure, although it renders the clearing of the bone more easy, is not necessary. Some deformity is produced, and the adjustment of the wound cannot be so carefully carried out. The point is not of primary importance, and in dealing with a large growth the knife may very properly be carried through the thickness of the lip.

Whenever possible, the symphysis should be saved. If it should be necessary to remove the median part of the bone with the genial tubercles, then the tongue must be prevented from falling back upon the larynx by means of a suitable silk ligature passed through its tip.

If the coronoid process be unduly long, or if it be pressed forwards by the growth of the tumour, it may hitch against the malar bone when the bone is depressed, and in such case must be divided with the chisel or bone forceps.

"In cases where the jaw has been extensively thinned or eroded by a growth, it is very likely to fracture under the depression which is required to bring down the condyle. If this accident occur, removal of the condyle and coronoid process is rendered difficult, as the latter is drawn upwards under the zygoma by the temporal muscle. The removal will be facilitated by dragging them down with lion-forceps and detaching the temporal tendon with blunt-pointed scissors" (Jacobson).

In dealing with growths of the maxilla it is undesirable that the periosteum should be saved.

In excision for necrosis, however, it is important that as little of that membrane as possible should be sacrificed.

PARTIAL EXCISIONS OF THE LOWER JAW.

Considerable portions of the jaw, but more especially of the alveolar part of it, can be removed from the mouth. Such operations are frequently called for in dealing with some of the many forms of epulis. Such a segment as is shown in Fig. 215, H can be readily removed. In effecting excisions of this limited character the chisel and mallet are the most useful instruments. Or the saw may be conveniently employed for the vertical incisions in the bone, and the chisel for the horizontal cuts.

It is well that the teeth in the involved segment should be removed should any still remain. The surgeon will add greatly to the difficulties of the operation if he attempts to drive a chisel or a saw through the fangs of several teeth.

If a portion of the body of the bone have to be excised, then it is always well to approach it by an incision made along the lower border of the maxilla.

Attempts to remove considerable segments of the body of the bone through the mouth are most unsatisfactory, lead to a needless mangling of the soft parts, to much bleeding, and to a sloughy pouch in the floor of the mouth.

The external incision enables the surgeon to reach the bone readily, to deal with it in the simplest manner, and to drain the wound cavity left after the excision.

Whenever possible, a portion of the lower part of the bone should be preserved, or, in other words, the lower border should never be divided unless it is inevitable.

If only a narrow bar of bone be left in this situation, it will prove of enormous value, not only in the after-treatment, but also in so far as the resulting deformity is concerned. The free use of the chisel enables much to be done in this direction.

If a portion of the maxilla, through its whole width, has to be removed, it is better, as Mr. Heath advises, not to complete one section before the other is begun, because of the loss of resistance consequent upon breaking the continuity of the bone.

Each cut should be carried nearly through the bone by means of the saw, and should then be completed with the bone-forceps.

"The removal of the central portion of the jaw," writes Sir William MacCormac, "leads to considerable functional trouble later, from the difficulty of keeping the ends apart and preserving the parallelism of the teeth. This must be striven for by the use of suitable apparatus, but the result is usually unsatisfactory."

THE REMOVAL OF THE WHOLE OF THE LOWER JAW.

This operation has been performed in a fair number of cases. In Weber's table twenty cases are alluded to. The excision is reputed to have been first carried out by Blandin in 1848.

The procedure requires no special description. The vertical chin incision is omitted, and the knife is carried along the whole of the lower border of the jaw on both sides, and terminates posteriorly in the manner already described.

The After-treatment.—The general features of the after-treatment have been alluded to in dealing with the upper jaw. The main difficulty is to keep the mouth sweet. A large pouch is left in the floor of the mouth, and in this pouch food and the secretions of the mouth must of necessity collect, and here they are apt to decompose. If no care be taken, this pouch becomes the seat of the foullest possible sloughs.

It is very difficult for the patient to wash the mouth out efficiently, as it is painful to move the remaining portion of the jaw, and even to move the head. The best wash is a 1-80 to 1-60 solution of carbolic acid.

For the first few days—if possible, for the first ten days—it will be well if the food can be administered through a tube, so that none can find its way into the mouth. If this be done, and if the mouth be washed out every hour with a gentle stream from an irrigator, the parts can be kept in excellent condition, and healing will proceed rapidly.

If a drainage-tube be employed, it should be removed in twenty-four hours, and the escape of the fluids in the mouth through the skin-wound should not be encouraged after that time.

The patient should occupy the sitting position as much as possible, and every care should be taken that he is well fed. In the manner of feeding I have usually employed the nasal tube, which has been passed after a little cocaine had been introduced into the nose through a spray-producer.

The foulness of the mouth in a neglected case is indescribable, and the persistent attempt to avert decomposition is a main element in the after-treatment.

Results.—Mr. Butlin has collected 104 cases of excision of the lower jaw for tumour. Of these, 14 died from the effects of the operation, showing a mortality of rather less than 14 per cent.

The chief causes of death have been exhaustion, pyæmia, erysipelas, and lung complications.

Speaking of malignant growths (sarcomata) of the lower jaw, Mr. Butlin considers that the prognosis in subperiosteal sarcoma is, in spite of early and free operation, very bad, on account of the rapidity with which the disease involves the neighbouring structures, and recurs after removal.

In cases of central sarcoma the prognosis is not so bad, provided that the resection of the bone has been free, and especially when the growth is of the giant-celled or myeloid type.

OPERATIONS FOR THE RELIEF OF CLOSURE OF THE JAW.

These operations are only adapted for severe cases which have resisted all milder measures, and in which the closure or the anchylosis is such as to cause grave inconvenience.

So far as the bone is concerned, two operations may be employed in dealing with this condition.

They are susceptible of modification, but they represent elementary principles in the treatment.

One operation would be ranked with cuneiform osteotomies; the other has been described as an excision of the temporo-maxillary articulation.

The two procedures are Esmarch's operation, and the removal of the condyle of the lower jaw.

1. Esmarch's Operation.

In this operation a wedge-shaped piece of bone is removed from the horizontal portion of the maxilla, with the intention of establishing a false joint.

This method is intended for those cases in which the trouble is *not* limited to the articulation. It is especially employed in examples of closure of the jaw due to the contraction of cicatrices. Such contraction is apt to follow destructive forms of inflammation, of which cancrum oris is a good example.

The *wedge* of bone to be removed must be taken from the horizontal ramus of the jaw, anterior to the masseter, and in front of the contracted tissues. The base of the wedge will be below, and in an ordinary case in an adult should measure one inch and a quarter. The apex is at the alveolar border, and should be about three-quarters of an inch in width (Fig. 215, I).

An incision some two inches in length is made along the lower border of the jaw at the spot at which it is intended to remove the wedge. The bone having been well exposed and the periosteum divided, a wedge of bone is removed with a key-hole saw, aided by the chisel and a periosteal elevator. After all bleeding has been checked the wound is closed by sutures.

It is essential that passive movements should be commenced within a day or two of the operation, and should be regularly maintained. By means of screw gags and graduated pieces of cork the patient should be encouraged to open the mouth as wide as possible, and to cultivate active movements of the new joint. Unless care be taken in this matter, the trouble is very apt to relapse. If great pain be experienced in moving the jaw, then the passive movements may be practised under gas on the first few occasions.

Very good results have been obtained by this method, and very useful, though one-sided, masticatory power is obtained.

2. **Excision of the Condyle of the Jaw.**

This operation is identical with the so-called excision of the temporo-maxillary articulation.

It has been carried out in some instances of suppurative joint-disease. Usually, however, it has been applied to cases of chronic rheumatoid arthritis, with deformity and great impairment of movement, and to cases of closure of the jaw due to mischief limited to the articulation itself.

A vertical incision is made over the site of the joint and condyle. It is placed anterior to the temporal artery, starts

at the lower margin of the zygoma, and ends below, just short of the transverse facial artery. The temporal artery may be considered to run about a finger's-breadth in front of the tragus, while the transverse facial artery is a little less than a finger's-breadth below the zygoma.

This incision may be joined by a second cut, which, starting from its upper extremity, follows the lower margin of the zygoma for about one inch.

The triangular flap thus marked out is reflected forwards. Care is taken not to damage any branches of the facial nerve nor any lobe of the parotid gland.

Such fibres of the masseter as come into view are separated from the zygoma, the capsule of the joint is exposed and opened, and the condyle brought well into view.

The neck of the condyle is now steadied by means of a small blunt hook, and is divided either with a chisel or a key-hole saw.

The condyle is then seized with forceps, and is twisted out with the left hand, while the surgeon severs any remaining connections with a scalpel held in the right. Throughout the whole operation it is important that all instruments employed should be kept close to the bone.

If necessary, a little more bone at the base or root of the condyle may be removed, or it may be desirable to repeat the operation upon the opposite side. The fibro-cartilage is not removed.

A small drain may be introduced and retained for twenty-four hours, and the wound closed with sutures. Some slight and quite temporary facial paralysis may exist for some days after the operation.

The after-treatment advised in connection with the previous operation must be here employed.

Unless such treatment be perseveringly followed, the condition is apt to relapse.

The results obtained have been on the whole excellent. A typical case is reported by Mr. Page of Newcastle (*Brit. Med. Journ.*, Dec. 10, 1887). Mr. Page has treated other cases since this date with equal success.

There is nothing to commend the operation of removing the condyle through the mouth without external wound.

Part VII.

TENOTOMY,

INCLUDING OPERATIONS FOR THE DIVISION OF CONTRACTED MUSCLES, LIGAMENTS, AND FASCIÆ.

THE term tenotomy is applied very obviously to the cutting of a tendon, and myotomy to the division of a muscle.

The term myo-tenotomy has been applied to such operations as involve the cutting of both muscular and tendinous fibres, as in the usual section of the sterno-mastoid muscle. Mr. R. W. Parker has given to his operation for dividing certain ligamentous structures in club-foot the name of "Syndesmotomy," *i.e.*, a cutting of ligament. Aponeurotomy has been associated with the division of bands of contracted fascia.

The first operation of tenotomy is ascribed to Roonhuysen of Amsterdam, who divided the sterno-mastoid tendon in 1670 ("Historische Heilcuren," Nürnberg, 1674, ob. xxii.). All the earlier operations were carried out by the open method. The tendon was exposed by reflecting the skin, and was then divided.

Later, we find that a knife was introduced beneath such a tendon as the tendo Achillis, and that that structure was divided simultaneously with the skin that covered it.

Delpech laid down the principles of the subcutaneous method of operating as practised at the present day (*Chirurgie Clinique de Montpellier*, 1823, t. i., page 184).

It is remarkable, however, that he did not carry out his principles, for in dividing the Achilles tendon he made a cut on each side of the tendon one inch in length.

Astley Cooper ("On Dislocations and Fractures," 6th ed., 1829, page 476) employed the subcutaneous method for dealing with contracted fasciæ in the hand.

To Stromeyer is due the main credit of introducing the subcutaneous method into practice. He first applied it to the Achilles tendon in 1831.

The history of this subject is admirably dealt with in Dr. Little's "Treatise on Club-foot" (London, 1839).

GENERAL CONSIDERATIONS.

1. **The Subcutaneous Method.**—The object of this method is to divide the tendon with the least disturbance of the surrounding parts, and with the smallest possible division of the skin. Air is not admitted to the deep wound; the risk of sepsis is thus minimised, and the surface puncture heals readily and surely. Before the introduction of the antiseptic method of treating wounds, the subcutaneous operation was all-essential. At the present time it should be carried out whenever convenient and possible. It must be remembered, however, that in the subcutaneous operation the surgeon is cutting a little in the dark, and in dividing such tendons as that of the tibialis posticus and the sterno-mastoid considerable damage has been inflicted by the movements of the invisible blade beneath the skin. This perhaps more especially applies to fat infants and to examples of extreme deformity.

Since the conditions which rendered the subcutaneous method essential are now no longer all-important, it is well not to adhere too blindly to the principle; and in any case in which the tendon is difficult to discover, and in which its relations with nerves and vessels are complex and intimate, it is better to return to the open method of the older surgeons, and to expose the area of the operation by a free incision.

With these exceptions the subcutaneous operation should be always adopted.

There is no need to draw the skin aside before making the puncture in order that the wound in the skin may not correspond to the wound of the deeper parts when the operation is complete. Such a method is embarrassing, and adds a needless difficulty to a simple procedure. The skin, moreover, may be unnecessarily cut by the knife against which it is strained.

It must not be assumed that because the subcutaneous

method is employed, no care need be taken to ensure an aseptic environment for the little operation.

The parts should be well scrubbed with some carbolic solution; the tenotomes should be absolutely clean, and should be placed in a solution of carbolic acid before being used.

2. **The Use of the Tenotome.**—The tendon or band of fascia to be divided is usually unduly prominent, or can be readily made distinct. The tendon should, if possible, be so cut as to avoid opening a synovial sheath.

The tenotome should be lightly held, as one would hold a pen. The sharp-pointed instrument is carefully introduced close to the tendon, and makes a way for the blunt-pointed instrument. It is essential that it should make an ample passage for the blunt-pointed tenotome, and therefore the cutting-point may need to be moved freely to and fro in the region of the tendon. If this be not done, the blunt tenotome may have to be forced to its destination through tissues that have been merely punctured.

The sharp tenotome is withdrawn, and the blunt instrument introduced, with the blade "flat"—that is, in a line with the line of the skin wound.

The instrument should throughout be kept close to the tendon or band to be divided, and care must be taken to avoid damage to adjacent vessels or nerves. The breaking of the point of the tenotome against the bone is not a very infrequent accident.

As the tenotomes are being introduced the tendon should be only stretched to such an extent as is necessary to render its position distinct. It needs to be stretched to its utmost when its fibres are being divided, but this tension may be a little relaxed as the last strands are being cut. The tendon is divided with a sawing movement; it cuts with a creaking sound or sensation, and yields finally with a snap. A common source of failure after this operation is due to an incomplete division of the tendon.

The left forefinger should be kept upon the skin at the site of the operation, in order that the movements of the tenotomes beneath the integument may be followed and guarded.

It is not usually desirable to do the whole operation with

the sharp tenotome only. In dealing with certain bands of contracted fascia and some few tendons, the one instrument may be employed. But in most cases, especially when the tendon is surrounded by tissues of importance, the two instruments should be made use of—the sharp-pointed tenotome to divide the skin and the fascia about the tendon, and the blunt-pointed instrument to sever the tendon itself.

This operation *à deux temps* involves a little more time, and is a little less brilliant, but it is safer and more satisfactory.

3. **The After-treatment.**—The operation is practically bloodless, and the only dressing needed is a pledget of wool dusted with iodoform. In forty-eight hours the little puncture may be considered to be healed.

The only factor in the after-treatment which has been the subject of much difference of opinion has to do with the adjustment of the limb after the tenotomy.

The discussion upon this subject has been practically limited to the treatment of cases of club-foot, and the question has been—Should the foot be immediately restored to its normal position after tenotomy, or should it be put up for a while in the deformed or original position?

The following book and papers bearing upon the matter may be consulted:—"Congenital Club-Foot, its Nature and Treatment," by R. W. Parker, 1887; and articles by Dr. R. Sayre (*Alabama Med. and Surg. Journal*, July, 1886), Mr. Howard Marsh (*Lancet*, Feb. 18th, 1888), Discussion on the Operative Treatment of Club-Foot (*British Medical Journal*, Oct. 27th, 1888), and a paper by Mr. Walsham (*Lancet*, May 19th, 1888). Mr. Walsham gives the following general review of the subject, and with his conclusions my own experience leads me to agree:—"As regards the restoration of the foot after tenotomy, there may be said to be three chief methods in vogue. (1) The *slow*, in which the ends of the tendon are placed in contact for a few days, and after union has taken place the new material uniting the ends is slowly stretched. (2) The *rapid*, in which a slight interval is left between the ends of the tendon, and the foot placed in plaster of Paris for a week, after which the plaster is reapplied twice or thrice, at intervals of about a week, the foot on each occasion

being forced into a better position." (This method is advocated by Mr. Howard Marsh.) "And (3) the *immediate* method, in which a considerable space is left between the ends of the divided tendon, the foot being at once secured in the normal position in plaster of Paris." Mr. Walsham having pointed out that the rapid method is a great improvement upon the slow, and that the immediate method is a still further advance upon the rapid, concludes as follows:—"The advantages of the *immediate* method, as well as of the *rapid* method over the *slow*, are—Great saving of time, and the doing away with the necessity of an expensive extension apparatus. The disadvantages attending the *rapid*, but which do not apply to the *immediate*, are—That considerable pain is often caused by the force which has to be employed in stretching the uniting material at each changing of the plaster, and that in severe cases the reparative material cannot always be stretched sufficiently to overcome the deformity, and it is occasionally necessary to re-divide the tendon." It has been clearly shown that in both the *rapid* and the *immediate* methods there is no failure in the uniting material which joins the ends of the divided tendon, nor has the uniting band remained weak or elongated. The possibility of this occurrence has been the main argument in favour of the *slow* method.

The above remarks refer for the most part to infants and children. In dealing with large tendons—such as the tendo Achillis in adults—it is desirable still to adhere to the slow method, to allow the limb to remain for some days or a week in the deformed attitude, and then to gradually correct the false position. In not a few instances in which the limb has been adjusted in what may be termed the normal position, after the accidental rupture or division of a large tendon in an adult, the union between the separated ends has been feeble and inefficient.

4. **The Instruments Used.** — Sharp and blunt-pointed tenotomes, with straight blades, are the only instruments needed. These knives must vary, both in size and strength, according to the proportions of the structure requiring division. There should be a mark upon the handle to indicate the position of the cutting edge when the blade is out of view.

The sickle-shaped tenotomy knife is seldom used in Great Britain, and figures in but few English catalogues.

PARTICULAR OPERATIONS.

Tibialis Anticus Tendon.—This tendon descends through the innermost sheath of the annular ligament, and crossing the ankle-joint, astragalus, scaphoid, and internal cuneiform bones, is inserted into the inner side of the last-named bone and the base of the first metatarsal bone. The synovial sheath which accompanies it extends upwards for some distance above the level of the malleoli. A small bursa lies beneath the tendon as it crosses the cuneiform bone.

This tendon is usually divided as it is crossing the scaphoid bone, and consequently about one inch above its insertion. At this point it should be free of its synovial sheath. The dorsalis pedis vessels lie to the outer side, with the extensor proprius pollicis tendon intervening.

In cases of congenital club-foot the tendon is displaced inwards, and is nearer to the malleolus. It is readily made prominent.

Operation.—The surgeon stands on the outer side of the limb in the case of either tendon. The assistant, who takes his place opposite to him, grasps the foot with one hand and the leg with the other. The foot is held in the position of extension and abduction, and the tendon is defined. The sharp tenotome is then entered vertically upon the outer side of the tendon, and is pushed downwards until it has reached a point below the level of the tendon. The operator's left forefinger is kept over the skin upon the plantar side of the tendon as a guard upon the instrument. The tendon is put on the stretch. The sharp tenotome is withdrawn, and the blunt-pointed one inserted in its place. After it has reached the depth acquired by the first instrument (whose tract it exactly follows) the foot is relaxed, and the blunt point is pushed nearly horizontally beneath the tendon, and may be felt on its plantar side. The tendon is once more put upon the stretch, and is divided by cutting upwards towards the skin. The left forefinger lies upon the skin over the edge of the knife, and forms a certain check to its movement. The surgeon cuts, indeed, upon the left finger, the skin intervening.

Tibialis Posticus Tendon.—The tendon becomes free of muscular fibres about the level of the tibio-fibular articulation. It grooves the back of the inner malleolus, running in the innermost compartment of the internal annular ligament. Behind the malleolus it is invested in a synovial sheath. The flexor longus digitorum tendon lies next to it (to its outer side), and is provided with a separate synovial sheath. External to this latter tendon run the posterior tibial vessels.

The tendon is usually divided above the point of commencement of its synovial sheath, *i.e.*, about the level of the base of the malleolus, and therefore above the inner annular ligament. The tendon is here easily approached, and is at some distance from the blood-vessels. Weis and Velpeau recommended division of the tendon at its insertion into the scaphoid bone. No advantage has been claimed for this method, and it is inapplicable to infants.

The tendon has been severed a little way below the tip of the malleolus. The selection of this point is to be condemned. The synovial sheath must be opened; the tendon lies close to the ankle-joint, and is in more intimate relation with the accompanying blood-vessels than it is at the spot usually selected.

Operation.—The surgeon stands to the outer side of the limb in the case of either tendon. The assistant faces him, and grasps the foot with one hand, and the leg with the other.

The position of the tendon is made out, and the foot is held a little extended and abducted, and is so turned as to lie upon its outer side.

The surgeon seeks for that point on the inner surface of the tibia where the malleolus joins the shaft of the bone. He reaches this point by following the posterior margin of the malleolus. The spot in question will be about a finger's breadth above the tip of the malleolus in the infant, and about one and a half to two inches above that process in the adult. It is really on the shaft, and is above what would be called, anatomically, the base of the malleolus.

The surgeon fixes his left thumb-nail upon the margin of the bone, and enters the sharp tenotome vertically between the tibia and the tendon, using the nail as a guide. The instrument should be kept as near as possible to the bone.

If properly inserted it will remain, as Mr. Heath has pointed out, fixed, without any support of the hand. The tendon should not be too tightly stretched at this stage of the operation.

The fascia about the tendon should be freely divided by moving the point of the instrument to and fro, but without enlarging the skin-wound. Unless this be done, a proper way may not be made for the blunt-pointed instrument.

As the sharp tenotome is withdrawn the blunt one is introduced—the edge is turned towards the tendon, the tendon is put upon the stretch and is divided by cutting from the bone. The left forefinger, placed over the site of the tendon, forms a guide and a guard. The tendon of the flexor longus digitorum is usually cut at the same time, and is often divided unconsciously.

The assistant should judiciously relax the strain upon the tendon as its fibres are divided.

It is obvious that if little care be taken the knife may cut through both the tendons, as through tightly-drawn cords, and may wound the main artery beyond.

If the blood-vessels should be divided, well-adjusted pressure must be at once applied to the spot.

Singularly little trouble appears to have supervened in examples of this accident.

The position of the tendon may be difficult to make out in a case of talipes varus in an infant, and in connection with this point the following observations by Dr. Little may be quoted :—" When the surgeon cannot feel the tendon, it is practically quite sufficient to make out the inner edge of the tibia, about a finger's-breadth above the lower end of the inner malleolus ; or should there be any difficulty in defining this ridge of bone in consequence of the fatness of the limb, the careful insertion of the knife exactly midway between the anterior and posterior borders of the leg, on its inner aspect, will be an exact guide to the position of the tendon, not forgetting, as anatomy teaches us, that an incision made a little in front of this line might wound the internal saphenous vein and nerve ; and if made behind, would run the risk of dividing the flexor communis digitorum, instead of the tibialis posticus ; or the knife might

even pass posterior to the former tendon, and, if carried deep enough, might wound the artery and nerve without touching any tendon whatever."

Plantar Fascia, Muscles and Ligaments of the Sole of the Foot.

These operations are concerned principally with cases of congenital talipes varus, and notably with such examples as are associated with considerable incurving of the sole. In the practice of some surgeons these plantar operations constitute the sole operative treatment of club-foot, if exception be made of tenotomy of the tendo Achillis.

The plantar fascia consists of a central and of two lateral portions. The central part—which was originally the plantar portion of the plantaris tendon—is the segment dealt with. Its great density is well known. It splits up into slips for the toes in front, while behind it becomes much narrowed, and is attached to the inner tubercle of the os calcis.

It is closely connected with the flexor brevis digitorum muscle, which it covers. The ultimate fibres of this fascia are intimately associated with the skin.

Simple Division of the Plantar Fascia.—The sole of the foot is well exposed, and the limb is firmly held by an assistant. The resisting bands of the plantar fascia are made out by putting the parts upon the stretch. The part usually divided will be a little in front of the attachment of the fascia to the os calcis, or close to the transverse markings near the heel, which are conspicuous in severe talipes varus (Fig. 220).

A very fine, narrow, and short-bladed tenotome is employed, and is introduced between the fascia and the skin. The edge having been turned towards the resisting band, it is divided by cutting towards the depths of the sole, *i.e.*, away from the skin.

The depth to which the cutting is continued must depend upon the thickness of the contracted tissue.

The surgeon would naturally avoid points where the fascia has become closely attached to the skin.

As a rule the contracted tissue will need to be severed at several points, and these multiple punctures are more efficacious than one single incision.

Buchanan's Operation.—The following method is adopted by Dr. Buchanan of Glasgow. The proceeding is applied to cases of talipes varus in children, "in which the abnormal position of the bones is maintained by such a degree of tension and rigidity of the soft parts as renders reduction by hand practically impossible without the division of the offending structures."

Fig. 220.—SOLE OF THE FOOT IN TALIPES VARUS, TO SHOW THE CREASES ON THE SKIN. (*Modified from R. W. Parker.*)

The following is Dr. Buchanan's description:—"The sections I find it usually necessary to make are first, always, the tendo Achillis, to relieve the equinus part. I never divide the tibialis posticus behind the ankle, being satisfied that such a muscle, as well as all the other muscles arising in the leg and inserted into the foot, can be stretched by sufficient manipulation; but, secondly, the structures which do maintain the incurved form of the foot, the plantar fascia and the muscular substance attached to it—namely, the abductor pollicis and the adjoining half of the flexor brevis digitorum; probably also the part of the deep plantar ligament which binds the astragalus to the scaphoid and other bones distal to it. In order to divide these, which I consider the most resisting tissues, I enter a tenotomy knife at the inner edge of the foot opposite the tuberosity of the scaphoid bone, pass it flatly superficial to the plantar fascia till the point reaches the middle of the sole of the foot; I now turn the edge of the knife vertical, elevate the handle to depress the point, and cut through and through the plantar fascia and the muscles underneath it till the point is over the articulation between the head of the astragalus and cup of the scaphoid bone. Here the point is made to cut through the tendon of the tibialis posticus proximal to its insertion into the scaphoid tuberosity, and by the same cut the deep ligamentous fibres are divided, thus completely freeing the

astragalo-scaphoid ball-and-socket joint, which is really the one on which the incurvation of the foot hinges. In doing this the external plantar nerve is wounded, but in my experience it always unites—at least, never loses its function. So also the internal plantar artery is divided; but it is a small vessel, and never gives trouble, the foot being nourished by the deep plantar arch from the external plantar artery. In my own experience, involving a large number of operations, and in the practice of others who adopt my operation, including most of those who have been educated in this university and others who have read my papers, not an accident has ever occurred from this somewhat heroic incision; but it has been attended with most fortunate results" (*Brit. Med. Journ.*, October 27, 1888). This operation is, as the author observes, heroic, and will probably not commend itself to cautious surgeons.

Parker's Operation—Syndesmotomy.—In cases of congenital talipes varus in children Mr. R. W. Parker is disposed to attach much more importance to the division of ligaments and the plantar fascia than to pure tenotomy. "With the exception of the tendo Achillis," he writes, "I think tenotomy in club-foot might be almost abandoned as a separate and independent operation. The two other tendons most frequently cut are the tibials, anterior and posterior. I believe, if it is necessary to divide them, that it should be done simultaneously with the ligaments with which they are closely associated, and this is most advantageously done at or near their insertions, where they spread out as fibrous expansions closely blended with the capsular ligaments connecting the head of the astragalus with the scaphoid, the scaphoid with the internal cuneiform, and this latter with the base of the first metatarsal bone, all these joints being much approximated by the incurvation of the inner border of the foot." This ligamentous tissue Mr. Parker calls the astragalo-scaphoid capsule, and he endeavours to combine a division of it with simultaneous division of the two tibial tendons. He terms the operation "Syndesmotomy."

The site chosen for this combined section of ligaments and tendons is a spot a little below and in front of the tip of the

inner malleolus, over the site of the astragalo-scaphoid joint, and in the situation of the transverse mark near the heel which is to be observed in severe talipes (Fig. 220). Two tenotomes are needed—an ordinary sharp-pointed tenotome, and a curved one of sickle shape with a cutting edge about half an inch in length.

The Operation.—The foot is so placed as to fully expose its inner border, and is firmly held; the position of the tendons and the arteries is made out so far as is possible.

At the spot above mentioned the sharp tenotome is entered. It should enter in front of the bifurcation of the posterior tibial artery, and behind the posterior tibial tendon. The knife is pushed forwards and outwards under the skin until a spot on the dorsum is reached just internal to the anterior tibial artery. The sharp instrument, which has made a tract merely, is withdrawn. The curved tenotome is now inserted flat-wise under the skin, and follows the subcutaneous course already made until its point can be felt over the tibialis anticus tendon. The edge is turned towards the tendon, and is made to cut to the bone. It severs the tendon, and as it is withdrawn is made in like manner to cut the dense ligamentous tissue already described. Just as it is being withdrawn it is made to sever the tendon of the tibialis posticus.

During the introduction of the instruments the foot is relaxed. During the cutting of the tissues it is put upon the stretch, and the yielding of the divided ligaments and tendons is made very evident.

Although the internal saphenous vein must lie across the incision, the bleeding is usually quite insignificant.

This operation has been extensively adopted, and has been attended with a considerable degree of success. It has an advantage over the procedure advised by Dr. Buchanan in so far as it is more precise and less heroic. Now that the treatment of wounds is conducted upon precise and successful principles, there is no reason why the subcutaneous method should be adhered to in this or allied operations.

The parts to be severed might be exposed by turning up a small flap of skin, which could be replaced and secured by sutures after the division had been completed.

Tendo Achillis.—This very powerful tendon measures in the adult some four and a half inches in length, three-quarters of an inch in breadth, and a quarter of an inch in thickness.

It is best divided at its narrowest part, *i.e.*, about one inch above its insertion.

Operation.—The patient may lie upon the back, with the body a little rolled over towards the affected side.

The foot is so turned as to lie entirely upon its outer side, and a small cushion placed beneath the lower part of the leg will carry the heel off the table.

The surgeon stands to the outer side of the limb, in the case of both the right and the left foot.

An assistant standing by his side holds the foot. Another assistant may steady the leg.

The tendon having been defined is rendered a little tense, but is not fully stretched. The sharp tenotome is entered vertically at the inner margin of the tendon, and is pushed downwards—in the present position of the foot—until it has reached the outer side of the tendon, where its point can be indistinctly felt. The sharp-pointed instrument is now replaced by the blunt, which follows the tract already made until its point can in turn be detected through the skin. The instrument must be kept very close to the tendon. The tendon is now put well upon the stretch, and the cutting edge having been turned towards the surface, the tense cord is divided with a sawing movement, the left forefinger resting upon the skin over the site of the operation.

The divided ends separate with a snap, and unless care be taken just at the time when the tendon gives way, the integuments covering it may be divided by the suddenly-liberated knife.

The short saphenous vein lies very near, and usually just anterior to, the outer margin of the tendon. The nerve which accompanies it is as a rule anterior to the vein at a point one inch above the heel. The only structure in near relation to the inner border of the tendon is the unimportant calcaneo-plantar nerve.

Nothing but the grossest clumsiness could place the posterior tibial vessels in danger.

The beginner is apt to fall into two errors. In the first place, he does not push the knife far enough towards the outer side, and as a result leaves the most external fibres of the tendon undivided; or, on the other hand, in his anxiety to keep close to the tendon, he may thrust the sharp instrument through its deeper fibres, which at the completion of the operation are left uncut.

Some surgeons let the patient lie upon the face, with the foot overhanging the end of the table. They sit to operate, and having introduced the tenotome upon either the inner or the outer side, cut upwards.

Peroneus Longus and **Brevis.**—The tendons of the two peronei pass down in the hollow behind the outer malleolus, and form a groove upon that process of bone. Behind the malleolus they are contained in the same fibrous and synovial sheath beneath the annular ligament. The tendon of the peroneus brevis is placed next to the fibula as it turns below that bone. The tendon of the peroneus longus muscle is the more superficial of the two. They are both very close to the bone. On the outer side of the os calcis the tendons separate and acquire separate synovial sheaths.

Operation.—Both tendons are usually divided together at a point about one inch and a half above the tip of the malleolus. The section if made here will be above the synovial sheath. The patient is rolled over upon the sound side, and the foot is so placed that it rests upon its inner surface, with the outer aspect uppermost. A firm cushion is placed under the lower part of the leg, and the foot is extended over it. An assistant steadies the foot and leg. The tenotome is introduced at the spot mentioned, is inserted close to the fibula, between the bone and the tendons, and has to be carried a little obliquely. The peronei are rendered slack when the instrument is being introduced.

When the blunt-pointed tenotome is in position, the foot should be so held as to put the tendons upon the stretch, and they are divided by cutting from the bone, the skin being guarded in the usual way.

The short saphenous vein and nerve are posterior to the tendons at the place of election, and will not be endangered if the tenotome be kept close to the bone. The vein may be

damaged if the whole operation be carried out with a sharp-pointed instrument.

If it be necessary to divide one tendon and not the other, the two structures should be exposed through a small incision, and the selected tendon drawn forwards and divided. The elaborate methods given for the subcutaneous division of a single tendon behind the malleolus are of no practical value.

If one or both of the peronei be divided below the malleolus, it is as well to expose the tendons through a small incision, rather than cut blindly with a hidden knife. The peroneus brevis in the foot lies above the peroneus longus.

Extensor Longus Digitorum and **Peroneus Tertius.**— The extensor tendons can be conveniently divided in front of or just below the ankle. In the latter situation there is greater risk of injuring the dorsalis pedis artery.

The patient lies upon the back, with the foot extended. The surgeon places himself to the inner side of the limb. An assistant grasps the leg and foot. The tenotome is entered upon the inner side, between the tendon of the extensor proprius pollicis and the tendons to be divided.

The usual precautions are observed. The blade is guided beneath the tendons, and the operator cuts towards the skin. The assistant should take more care to prevent the foot from falling suddenly after the tenotomy than to put the tendons upon the stretch during the section.

The knife must be kept close to the tendons, and as superficial as possible.

At the ankle the anterior tibial vessels lie beneath the extensor proprius pollicis. On the dorsum of the foot the artery lies to the outer side of that tendon.

If the knife be not allowed to pass deeply, the blood-vessels are in no great danger.

Hamstring Tendons.—The biceps tendon can be very readily felt upon the outer side of the popliteal space. Just behind it, and along its inner border, lies the peroneal nerve, which can be easily defined and rolled under the finger.

Of the semi-tendinosus and semi-membranosus, the former tendon is the nearer to the middle line of the space, is more

superficial, more distinct, and more cord-like. The latter tendon is the most deeply placed of the three hamstrings, and is of large size.

These tendons are most conveniently severed just above the line of the knee-joint, and on a level with the most prominent part of the condyles of the femur.

Biceps.—The patient should lie as far as possible upon the face, so that the popliteal space might be well exposed.

The surgeon may stand upon the inner side of the limb in the case of either the right or the left tendon. If he place himself to the outer side of the extremity, he will face the patient when dealing with the left leg, and have his back to the patient when dealing with the right.

The leg is steadied by an assistant. With a sharp-pointed tenotome a puncture is made directly over the tendon, and the instrument is passed vertically downwards on the inner side of the tendon, and is withdrawn when it has passed a little way beyond it.

The blunt point is now introduced, and following the same line is passed vertically between the tendon and the nerve. When it has just passed beyond the tendon, the blade is turned outwards, the handle brought as nearly horizontal as possible, and the point passed beneath the biceps until it may be felt upon the outer side.

The tendon is then divided by cutting towards the skin, which is guarded with the left forefinger in the usual way. During the introduction of the tenotomes and the cutting of the tendon the biceps should be kept upon the stretch. As the knife is withdrawn the limb should be flexed.

If care be not taken, the knife may slip through the skin when the tendon gives with a snap.

In the conditions for which this operation is usually performed the contracted biceps tendon is drawn away from the nerve, and a wider interval than the normal separates the two structures.

After the tenotomy the nerve may spring into view, and may be mistaken for an undivided portion of the tendon.

Both in the class-room and in practice I have seen a

prominent and cord-like ilio-tibial band divided in the place of the biceps.

In some thin and muscular subjects the lower portion of this fascial band may feel very tendon-like.

Numerous contracted bands of fascia may come into view after tenotomy of the biceps for contracted knee. Some may need division. They are, however, better left alone, as they usually yield under extension, and in dealing with them by tenotomy unexpected vessels may be wounded.

Semi-tendinosus and **Semi-membranosus.** — The same observations as have been applied to the biceps apply generally to these tendons. They are most conveniently divided exactly opposite the spot selected for tenotomy of the biceps.

The tenotome is introduced upon the outer side of the tendon, and is passed beneath it. The steps of the little operation need not be repeated.

In one case Mr. Jacobson met with "most profuse" hæmorrhage in dividing the semi-membranosus tendon in a girl of sixteen. He considered that the bleeding—which was checked by pressure—proceeded from the superior internal articular artery.

TREATMENT OF DUPUYTREN'S CONTRACTION.

The exact anatomy of the palmar fascia should be borne in mind, and especially the manner in which the digital processes of the fascia are disposed of, and the connections of the ultimate slips of the fascia with the integument of the fingers.

The pathology of Dupuytren's contraction need not here be dwelt upon. It is for the relief of this condition that division of the palmar fascia is usually practised.

There are two methods of dealing with the contracted bands—the subcutaneous method and the open method. They are illustrated by the two operations described below.

1. **Adams' Operation.**—This consists in the division of the bands of fascia by the subcutaneous method, the sections being made at many points. The treatment of Dupuytren's contraction by subcutaneous division of the bands of fascia

appears to have originated with Sir Astley Cooper. In his work on "Dislocations and Fractures" (New Ed., 1842, page 511), he writes:—"When the palmar aponeurosis is the cause of the contraction, and the contracted band is narrow, it may with advantage be divided by a pointed bistoury, introduced through a very small wound in the integument. The finger is then extended, and a splint is applied to preserve it in a straight position."

The fingers usually concerned in the contraction are the ring and little fingers.

Operation.—A very fine and narrow tenotome is employed, which is introduced between the skin and the fascia, and is made to divide the band by cutting towards the depths of the palm, *i.e.*, from the skin. The points selected for the operation are spots where the skin of the palm is free from attachment to the fascia. The knife is introduced at right angles to the line of the contracted band, and the bent fingers are put well upon the stretch when the section is being made.

Care must be taken not to dip the point of the tenotome into the deeper parts of the palm, and to divide the fascia, and the fascia only. The situation of the palmar arteries must of course be regarded.

Multiple punctures are needed. In an ordinary case—in which two fingers are involved—from six to nine punctures will usually be required.

These punctures concern the palmar bands, and it is easy, by dividing them, to overcome the flexion of the metacarpo-phalangeal joints. The contraction that may remain in the fingers, and that will be limited to the first inter-phalangeal joint, is not so easily corrected. It may be relieved by minute subcutaneous divisions of the fascia, carried out with great care in the region of the web. It is needless to say that with the fascial bands in this position the digital arteries and nerves are closely associated.

The attempt to overcome at once all deformity of the finger should not be pressed too far, but Adams' splint, with rack-and-pinion movements opposite the metacarpo-phalangeal and inter-phalangeal joints, should be applied, and the deformity be gradually overcome.

In any case a splint must be worn for many weeks. The little punctures are dusted with iodoform, and dressed with cotton-wool.

In severe instances of the deformity a digital nerve has been either divided or torn, with the result that much pain has followed, or a little sloughing has occurred at the tip of the finger.

This operation has afforded very fair results, but it has been followed by a tendency to relapse, and so far as my own experience goes is neither so successful nor so sure as the treatment by the open method about to be described. This point is, however, discussed more fully on page 773.

2. **Hardie's Modification of Goyraud's Operation.**— Goyraud (Schmidt's *Jahrbücher*, 1835, page 248) made a longitudinal incision in the skin in the long axis of the contracted band, which, when exposed, was divided transversely. This operation was an improvement upon the open method of Dupuytren, who divided both skin and fascia by a simple transverse cut. It followed that when the deformity was corrected the wound gaped very considerably, and was, indeed, drawn quite asunder.

The following is Mr. Hardie's description (*Med. Chron.*, vol. i., page 9):—

"Esmarch's tourniquet having been applied, an incision is begun half an inch above the principal transverse fold of the palm, immediately over the tense bridle of fascia proceeding to the finger mainly involved. This is carried along the bridle to a little beyond the base of the last phalanx which is affected. The lips of the incision having been opened up, the knife is then carried close to the bridle along its whole extent, so as to separate from it the adjacent skin, cellular tissue, and fat, first on one side, and then on the other. In doing this, it is necessary to go some depth near the upper end of the incision, so as to divide the little bands which attach the web of the finger to the processes of fascia inserted into the sides of the first phalanx. This dissection having been completed, the tense bridle of fascia, now almost isolated, is cut across at the upper end of the incision. This immediately permits of an almost complete extension of the first phalanx. Further

transverse incisions are then made opposite the middle of the first and second phalanges, as the case may require. The knife is then applied to any portion of the fascia that seems to prevent complete extension of the fingers. Some portions may then appear to be so much isolated, or may project so much, that they may be cut out entirely. The other fingers of the same hand are then, in their turn, similarly treated. Complete capability of immediate extension is to be secured. The tourniquet is then removed, but although the bleeding will be very smart, it is not likely that any vessels will be seen which can be secured.

"I then lay a catgut or horse-hair drain along the extent of the wound, and bring the edges of the latter accurately together with silver wire. A large pad of antiseptic dressing is applied, and the fingers are bandaged to a straight splint. I regret to have to use a drain, but the bleeding is so free that I think it a desirable precaution. It should be removed next day, and the dressing re-applied so as to exert some pressure on the part. Should nothing untoward occur, it should be left undisturbed for a week, when it is to be expected that sound union will have taken place. The stitches are removed, and subsequent treatment will consist in manipulation of the fingers and the use of the splint for two or three weeks longer."

I have carried out this operation in five cases, with a perfectly satisfactory result in each instance. I do not apply a tourniquet, and believe that in consequence of the after-oozing it does not affect the loss of blood. The bleeding is not inconsiderable, but it ceases readily. I have never found it necessary to use a drain. I have in each case excised the bar of contracted fascia, or as much of it as was easily and safely removed. I have found that it is scarcely possible to adjust the edges of the wound accurately. The incision usually gapes a little. It heals slowly but soundly, and without any noticeable degree of suppuration. There is generally a little area left which closes by granulation. Catgut or fine silkworm-gut sutures were employed in each instance. The wound was well dusted with iodoform and dressed with a sponge. The splint was in each of the cases worn for a month. After that period the patient was

advised to rub and knead the affected palm and fingers daily, and to frequently practise passive and active extension of the involved digits.

The most strict antiseptic precautions should be observed throughout.

Comment.—Of the two operations the latter is certainly the more severe. It carries with it such slight risks as—at the present day—attend an open wound. The healing of the wound may be slow. There may be some swelling of the hand, and some pain. These are perhaps the main arguments against the measure. On the other hand, there are advantages attending an open wound. The surgeon does not cut in the dark, the operation area is well exposed, and the contracted bands can not only be divided with ease and certainty, but can be entirely removed. The skin, moreover, is very freely liberated over the whole of the affected district. The after-treatment is comparatively simple and of short duration. The results so far appear to have been eminently satisfactory.

In Adams' operation the actual operative measure is certainly slight, and the wound made may be practically disregarded. The after-treatment is, however, tedious. The principal importance attaches to the use of the splint, to "gradual, quiet, and persevering extension," so long continued as to lead to atrophy of the divided fascial bands. The adhesions of the contracted fascia to the skin are left untouched. The after-treatment is such that the procedure is but indifferently suited to hospital practice; and although admirable results have been claimed for the operation, still many examples of relapse are forthcoming.

DIVISION OF THE STERNO-MASTOID MUSCLE.

This muscle, or a portion of it, is divided just above its origin in certain cases of wry-neck. Sometimes division of the sternal tendon of the muscle suffices.

The tenotomy is best carried out about one-fourth of an inch above the upper border of the clavicle and sternum.

The sterno-mastoid is in this situation covered by the cervical fascia, and is crossed by the supra-sternal nerve. The anterior jugular vein passes behind it, just above the clavicle,

and is in danger of being wounded. This vein is, moreover, subject to considerable variation. The external jugular vein is in close relation with the posterior or outer border of the muscle.

The patients subjected to the operation are usually children; the muscle is prominent, and has by its contracted position been somewhat carried away from the subjacent vessels. It is, moreover, not infrequently converted into a comparatively narrow fibrous cord.

Tenotomy of a normal sterno-mastoid muscle would be a dangerous and a somewhat difficult operation, but the same degree of danger and difficulty does not attend the tenotomy as it is carried out in practice.

The division of the muscle in an adult body in an operative surgery class can be scarcely considered to represent the procedure which is carried out upon the living subject.

Operation.—The head and shoulders are well raised, and the trunk is brought close to the head of the table. The operation will be described as it would apply to the muscle of the *right* side.

The surgeon stands upon the affected side, and facing the patient. An assistant placed at the opposite side of the table so holds the head as to place the muscle upon the stretch.

The sternal and clavicular portions of the muscle should be divided separately.

With a sharp-pointed tenotome a very small vertical incision is made along the inner or anterior border of the muscle (the sternal tendon). The fascia is divided, and the tendinous margin is clearly reached. A blunt-pointed tenotome is now introduced, is passed down to the tendon and then behind, and is thrust along horizontally and on the flat, until its point can be felt in the gap between the clavicular and sternal portions of the muscle. It must be kept as close to the muscle as possible.

The edge is now turned towards the tendon, which is divided by cutting towards the skin.

The surgeon's left forefinger is placed as a guard over the integument covering the site of the tenotomy.

The sharp tenotome is in like manner entered at the posterior or outer border of the muscle, and the blunt instrument introduced and manipulated in the same way. The clavicular part of the muscle is then divided in the same manner as was the sternal portion. It will be noticed that, to divide the former, the knife is introduced from without in, and to divide the latter from within out. If more convenient, the puncture for the clavicular portion may be also made on the inner side, but this procedure involves a little more risk to the external jugular vein.

The surgeon may be disappointed to find that after the operation he is still unable to entirely correct the deformity. This will depend rather upon coincident contractions of the cervical fascia and the scalene muscles, than upon an insufficient section of the sterno-mastoid.

In dealing with the *left* muscle, the operator will find it convenient to stand beyond the upper end of the table and lean over the patient's head to operate (*i.e.*, he will face the patient's feet); or he may take up a corresponding position to that described in dealing with the right side, and may cut both portions of the muscle through punctures made on the outer or posterior side of the part to be divided, commencing with the clavicular head of the muscle.

Some surgeons recommend the following method:—

An incision is made at the anterior or inner border of the muscle, and through this a grooved director is passed beneath the muscle, until its point can be felt at the posterior or outer border. A narrow probe-pointed bistoury is now introduced along the groove of the director, and the muscle is divided by cutting from the posterior to the anterior border, and from the deep-lying parts towards the skin.

This method is suited for the normal muscle, and for the operation as it is performed in the class-room; but it is not necessary in dealing with the usual cases requiring the operation in actual practice.

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